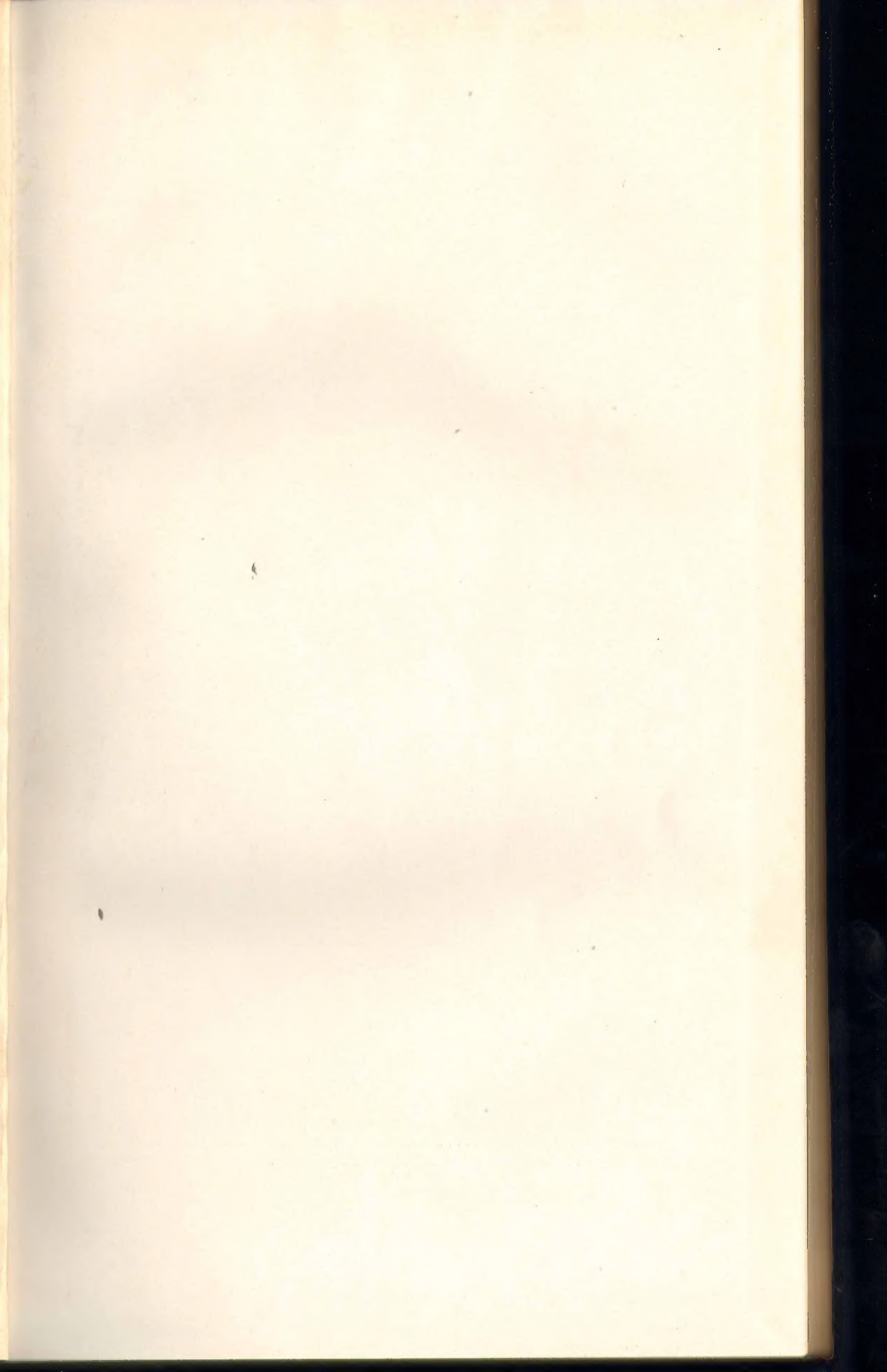


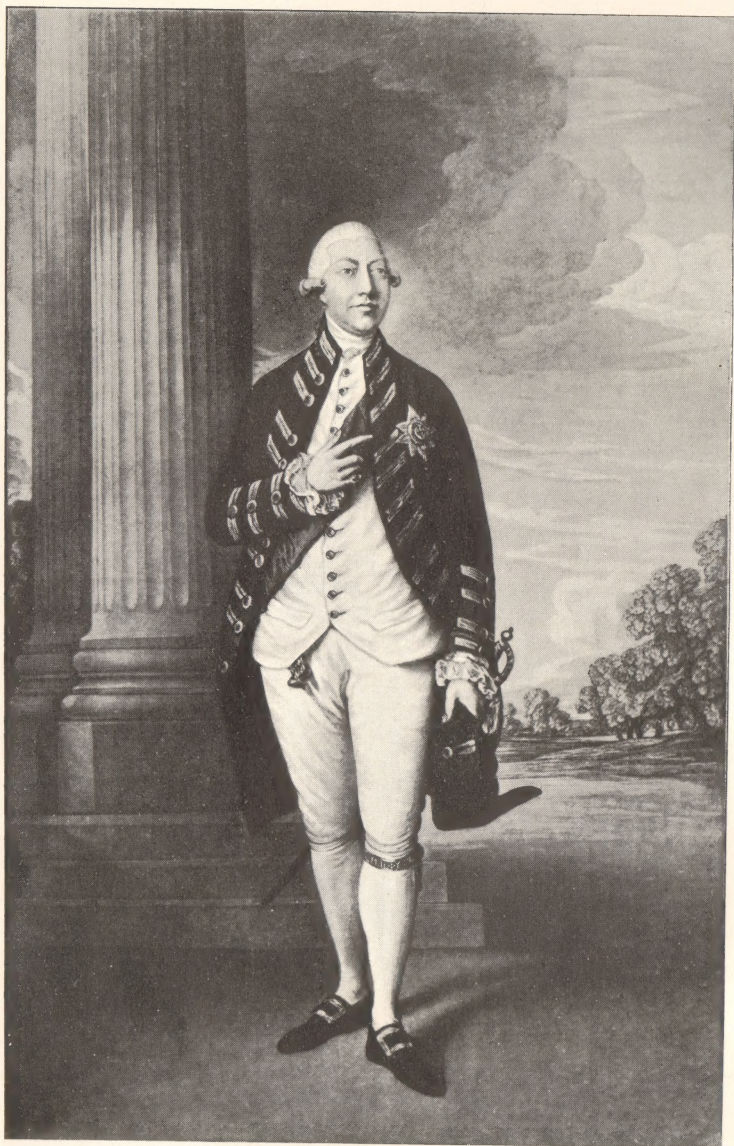
EARLY YEARS OF THE ORDNANCE SURVEY. CLOSE.

THE EARLY YEARS OF THE
ORDNANCE SURVEY.









KING GEORGE III.

(After Gainsborough).

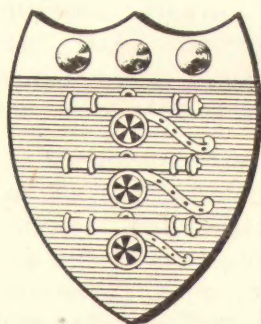
A generous and beneficent monarch, whose knowledge and love of the sciences were sufficiently evinced by the protection which he constantly afforded them, . . . supplied the funds that were judged necessary . . . for the first trigonometrical operation.

THE EARLY YEARS OF THE ORDNANCE SURVEY

BY

COLONEL SIR CHARLES CLOSE, K.B.E., C.B., C.M.G., F.R.S.

Sometime Director-General of the Ordnance Survey.



MONIMENTUM DECESSORUM SUCCESSORIBUS THESAURUS.

Reprinted from the ROYAL ENGINEERS JOURNAL

and

*Published by the Institution of Royal Engineers,
Chatham.*

1926.

THE FIELD ARTILLERY ORDNANCE REGIMENT

18

CHIEF OF THE REGIMENT
GENERAL



Published from the ROYAL ARTILLERY JOURNAL
and
Printed by the Institution of Royal Engineers,
Chatham.

1926

CONTENTS.

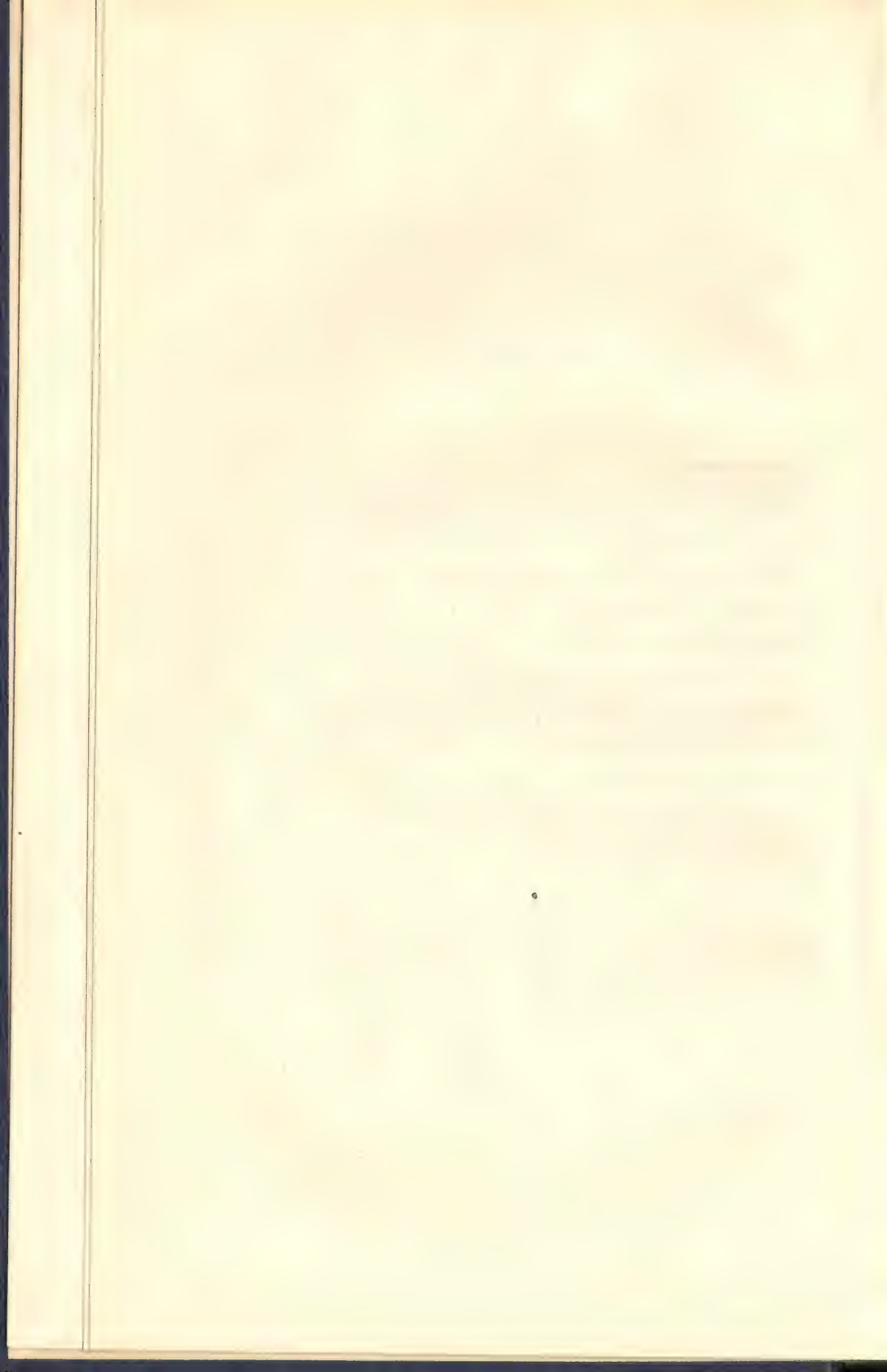
CHAPTER.	PAGE
<p>I.—THE SOURCES OF INFORMATION—"THE FORTY-FIVE" —THE MAP OF THE HIGHLANDS—WILLIAM ROY— ROY'S LETTERS—ROY AND RENNELL—THE SURVEYS OF FRANCE—THE SURVEYS OF GREAT BRITAIN IN 1783</p>	1
<p>II.—SCHEMES FOR A GENERAL SURVEY—THE THIRD CASSINI—RAMSDEN—THE GREAT CIRCULAR INSTRU- MENT—HOUNSLOW HEATH BASE—INSTRUMENT MAKERS—THE BASE TERMINALS—DELAYS—ROY'S LATER LETTERS—THE TRIANGULATION—ROMNEY MARSH BASE—ISAAC DALBY—ROY'S LAST DAYS ..</p>	12
<p>III.—THE DUKE OF RICHMOND—THE WORD "ORDNANCE" —EFFECT OF ROY'S DEATH—OFFICIAL FOUNDATION OF THE SURVEY—THE FIRST DIRECTOR—HEAD- QUARTERS OF THE SURVEY—THE ROYAL MILITARY SURVEYORS—OPERATIONS OF 1791-98—THE GEODESY OF THE OPERATIONS—THE ONE-INCH MAP—IN- ACCURACY OF THE OLD MAPS—THE FIELD WORK OF THE ONE-INCH MAP</p>	25
<p>IV.—WILLIAM MUDGE—WORK IN 1799—POSITION OF THE SCILLY ISLES—REFRACTION—THE FIRST ORDNANCE MAP—MUDGE'S ARC OF MERIDIAN—SIMON WOOLCOT</p>	39
<p>V.—COLBY JOINS THE SURVEY—PROGRESS OF THE WORK, 1800-09—HEIGHTS OF THE HILLS—"ACCOUNT OF THE TRIGONOMETRICAL SURVEY"—LETTERS FROM MUDGE—THE GEOLOGICAL SURVEY—DON RODRIGUEZ —PROGRESS OF THE WORK FROM 1810-1820—MORE LETTERS FROM MUDGE—WEST EUROPEAN ARC OF MERIDIAN</p>	53
<p>VI.—PROGRESS 1820-25—THOMAS DRUMMOND—JAMES GARDNER—ROBERT DAWSON—R. K. DAWSON ..</p>	71

CONTENTS.

CHAPTER	PAGE
VII.—THOMAS COLBY	83
VIII.—THE SEVENTEENTH CENTURY SURVEYS OF IRELAND— THE DOWN SURVEY—THE SELECT COMMITTEE ON THE SURVEY OF IRELAND—THE ORDNANCE SURVEY OF IRELAND IS BEGUN—FORMATION OF THE SURVEY COMPANIES—SOME DETAILS OF THE ADMINISTRATION —MOUNTJOY HOUSE—BOUNDARIES—THE CIVIL STAFF—THE ROYAL SAPPERS AND MINERS—THE LOUGH FOYLE BASE	99
IX.—COLBY'S SYSTEM—THE COMMITTEE OF ENQUIRY OF 1828—THE TRIANGULATION OF IRELAND—THE COUNTY MERIDIANS—PROGRESS OF THE SIX-INCH MAP, 1829-39—PORTLOCK—REID—LARCOM—IRISH PLACE-NAMES AND JOHN O'DONOVAN	119
X.—THE SIX-INCH SURVEY OF SCOTLAND AND THE NORTH OF ENGLAND—COMPLETION OF THE SIX-INCH SURVEY OF IRELAND—LEVELLING AND MEAN SEA-LEVEL— CONTOURS—THE FIRE IN THE TOWER OF LONDON— THE ORDNANCE SURVEY MOVES TO SOUTHAMPTON— AIRY—YOLLAND—COLBY'S SUCCESSOR—SOME MIS- CELLANEOUS LETTERS—THE STATE OF THE SURVEY IN 1846—THE END OF THE FIRST HUNDRED YEARS..	138

ILLUSTRATIONS.

	PAGE
KING GEORGE III. 	<i>Frontispiece</i>
PORTION OF A ROAD SURVEY BY WILLIAM ROY, 1756.. ..	4
RAMSDEN'S 3FT. THEODOLITE, 1787 	14
THE DUKE OF RICHMOND, 1735-1806	24
THE FIRST ORDNANCE MAP, 1801 	44
WILLIAM MUDGE, 1762-1820 	53
THOMAS DRUMMOND, 1797-1840.. 	76
HILL DRAWING OF SNOWDON BY R. DAWSON, 1820	80
THOMAS COLBY, 1784-1852 	98
MOUNTJOY, PHŒNIX PARK, DUBLIN	110
A PORTION OF THE DOWN SURVEY OF CO. KILDARE	112
THE FIRST SIX-INCH ORDNANCE MAP, 1831	126
J. E. PORTLOCK, 1794-1864 	128
JOHN O'DONOVAN, 1806-1861	134
RUINS OF THE GRAND STOREHOUSE, TOWER OF LONDON, 1841	144
SIR GEORGE AIRY, 1801-1892	148



NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.

WITH SOME ACCOUNT OF ITS FOUNDERS.

By COLONEL SIR CHARLES F. CLOSE, K.B.E., C.B., C.M.G., F.R.S.

INTRODUCTION.

The Sources of Information.—The period covered by these notes is the hundred years between 1746 and 1846. The Ordnance Survey did not formally exist during the whole of this period; but it is necessary, in order to show how it came into existence, to commence at the date first mentioned. The writer of these notes has been fortunate enough to be entrusted with the custody of a considerable number of letters and documents, hitherto unpublished, covering a large part of the period. The letters and documents were—in the main—collected by Major-General Thomas Colby,* F.R.S., who was Director of the Survey from 1820 to 1846. The writer is much indebted to Miss A. Colby and Miss C. Colby, the daughters of General Colby, for permission to make use of this collection, which includes some original letters written by General William Roy, who may justly be called the founder of the Survey.

Amongst other sources of information should be mentioned a book entitled *The Memoirs of the Mudge Family*, which contains an account of the life of General Mudge, F.R.S., who was Director of the Survey from 1798 to 1820. There is also a valuable addition to the literature of the subject in Mr. George Macdonald's *General William Roy and his Military Antiquities of the Romans in North Britain*, which was published by the Society of Antiquaries in 1917. And there are some old letter-books preserved in the Ordnance Survey Office at Southampton which occasionally throw some light on the early history of the Survey.

Of the sources of information that have already been used in the two little books on the Survey by Capt. H. S. Palmer (1873), and Lieut.-Colonel T. P. White (1886), it is only necessary to mention the various volumes of the *Philosophical Transactions* of the Royal Society; the *Memoir of the late Major-General Colby* by Lieut.-Colonel Portlock, F.R.S., printed in the *R.E. Professional Papers* for 1853–55–56, and the various technical publications of the Survey, ending, for this purpose, with Clarke's celebrated *Account of the Principal*

* Pronounced *Cole-by*.

Triangulation, (1858). The lives of Roy, Colby and Ramsden in the *Dictionary of National Biography* should also be mentioned.

I. ROY AND HIS TIMES.

The Forty-five.—About the middle of the eighteenth century the fortunes of this country were, for a time, in the hands of two young men—Charles Edward, the Young Pretender, grandson of James II.; and the Duke of Cumberland, son of George II. It is an old story how Charles Edward raised the standard of his father in August, 1745, how he and his troops occupied Edinburgh and Carlisle and marched as far south as Derby, were compelled to retreat, and were finally defeated by the Duke of Cumberland, at Culloden, on a misty, drizzly day in April, '46.

The Map of the Highlands.—It is not known what maps were used in this campaign by the Duke of Cumberland and his staff, but it is certain that they were very imperfect and that the Deputy Quarter-Master-General, Lieut.-General Watson, experienced the need for better ones. There were, in fact, no reliable maps available for the use of the Army, either in the operations which terminated in Culloden, or during the subsequent pacification of the country. General Watson therefore determined to make a map of the Highlands and it is from the commencement of this mapping of the Highlands, in 1747, that we should, perhaps, date the first idea of an Ordnance Survey, for the work was carried out, under the orders of the Government, by the Army. We have an authoritative account of the circumstances which gave rise to this undertaking, written by William Roy, and published in the *Philosophical Transactions* of the Royal Society for 1785. The interest of the matter may, perhaps, justify a lengthy extract. Roy says :

“ The rise and progress of the rebellion which broke out in the Highlands of Scotland in 1745, and which was finally suppressed by His Royal Highness the Duke of Cumberland at the battle of Culloden in the following year, convinced Government of what infinite importance it would be to the State that a country, so very inaccessible by nature, should be thoroughly explored and laid open, by establishing military posts in its inmost recesses, and carrying roads of communication to its remotest parts. With a view to the commencement of arrangements of this sort, a body of infantry was encamped at Fort Augustus in 1747, under the command of the late Lord Blakeney, at that time a Major-General; at which camp my much-respected friend, the late Lieut.-General Watson, then Deputy Quarter-Master General in North Britain, was officially employed. This officer, being himself an Engineer, active and indefatigable, a zealous promoter of every useful undertaking, and the warm and steady friend of the industrious, first conceived the idea of making a map of the Highlands. As Assistant Quarter-Master, it fell to my lot to begin, and afterwards to have a considerable share in, the execution of that map; which being undertaken under the auspices

of the Duke of Cumberland, and meant at first to be confined to the Highlands only, was nevertheless at last extended to the Lowlands; and thus made general in what related to the mainland of Scotland, the islands (excepting some lesser ones near the coast) not having been surveyed.

"Although this work, which is still in manuscript, and in an unfinished state, possessed considerable merit, and perfectly answered the purpose for which it was originally intended; yet having been carried out with instruments of the common, or even inferior kind, and the sum allowed for it being inadequate to the execution of so great a design in the best manner, it is rather to be considered as a magnificent military sketch, than a very accurate map of a country. It would, however, have been completed, and many of its imperfections no doubt remedied; but the breaking out of the war of 1755 prevented both, by furnishing service of other kind for those who had been employed upon it."

The original field sheets of this map are preserved in the King's Library in the British Museum, so far as concerns the greater part of Scotland, namely, that part which is north of the Forth and Clyde. There are a few scattered sheets south of this line. This "original protraction" covers 84 rolls of very varying sizes. The right and left edges of the sheets run roughly parallel to the magnetic north and south of the date of the work, that is, about 17° W. of true north.

The work is clearly an elaborate compass sketch; the roads and some of the streams have been paced, and the mountains have been put in roughly by eye. Near the towns the work is carefully drawn. Cultivation is indicated by open diagonal hatching. The hill-features are shown by rough, faint, brush, sepia shading or *hachuring*; the larger mountains are shown by similar, only darker, shading.

No sheet is dated and no sheet is signed. And this is a pity, because some very interesting men were employed on the work, in addition to Roy; for instance, David Dundas, afterwards Commander-in-Chief; and Paul Sandby, the artist, who was afterwards an instructor at the R.M. Academy.

The British Museum also holds the "fair protraction" of the map on the same scale and in the same style, but complete for the whole of Scotland except the islands. These fair drawings are folded in 38 sections, numbered systematically from south to north.

The scale of the map is apparently intended to be 1,000 yards to one inch, or 1:36,000, a scale which was never again adopted for official maps in this country. This scale lies between the 6-inch and the 1-inch scale, and it is possible that if it had been revived we should have used it in substitution for these scales. A map on the 1,000-yards scale covers about three times the area of ground that a 6-inch map covers on a piece of paper of the same size, and shows very nearly as much detail. The map was never printed, but a reduction on a single sheet was made by Roy before the spring

of 1774, when it was engraved, and ultimately published in the *Military Antiquities*. Mr. Macdonald quotes an extract from Roy's will, which is dated 13th November, 1786 :—

" I request that Colonel Dundas will take the pleasure of a most gracious Sovereign with regard to the manuscript map of Scotland remaining in my custody, he having been employed in the execution of that map." The complete large manuscript map and the rolls of the " original protraction " thus passed to the King's Library and thence to the British Museum—a very appropriate resting-place for them.

William Roy.—William Roy was born at Milton Head in Carluke parish, Lanarkshire, on the 4th May, 1726. He was educated at Carluke parish school and afterwards at Lanark. He appears to have held a minor position in the post office at Edinburgh until 1747.

In that year he states that he served as Assistant Quarter-Master under Lieut.-General Watson, then Deputy Quarter-Master-General in North Britain. He was never in the Artillery, as is sometimes stated, and it is not certain that he held any military rank in 1747. He was certainly not Assistant Quarter-Master-General in that year, as stated by Portlock.

Towards the end of the *Colby Memoir* Portlock gives a list of Roy's appointments in the Engineers. His name appears as Practitioner Engineer in the *Army List* of 1756, and he had been so appointed on the 23rd December, 1755. He received a commission in the 53rd Foot on the 4th January, 1756. He became Practitioner Engineer and Ensign of the New Corps of Engineers on May 14th, 1757 ; Sub-Engineer and Lieutenant, 1759 ; Captain in the same year ; Director and Lieut.-Colonel of Engineers, 1783 ; Colonel, 1785. In the Army his various ranks were always senior to those he held in the Corps. Thus—he was Lieut.-Colonel in the Army in 1762, Colonel in 1777, Major-General in 1781.

He was D.A.G. in 1764–65, D.Q.M.G. in 1766 and was appointed Colonel of the 30th Foot in 1786.

We may, perhaps, agree with Mr. Macdonald, when he says that during the construction of the map of Scotland, which was in progress from 1747 to 1755, Roy was not in the Army at all ; although the map was a military undertaking and Watson employed soldiers on the work. But if Roy was not formally in the Army when he was Assistant Quarter-Master, he worked with soldiers, and was closely identified with the Army, and shortly after the outbreak of the Seven Years' War, when he was not quite 30 years old, he received a commission, as stated above.

Roy was evidently recognized as a capable man, for in 1756 he was employed in making reconnaissances and plans in Great Britain ; in June, 1756, for instance, we find him employed in drawing a reconnaissance map, on the 1-inch scale, of the strip of country



Portion of a Road Survey from Salisbury to Dorchester by Lieut. W. Roy.

June, 1756. Scale 1" to 1 mile.

"Reconnoitred by Colonel D. Watson, Q.M.G. of H.M. Forces."



between Salisbury and Dorchester. In 1757 he took part in the expedition against Rochefort and later was present at the battle of Minden. He was D.Q.M.G. in Germany in 1760-61; then D.Q.M.G. to the Forces in South Britain; then in 1762 D.Q.M.G. in Germany. Then came the peace of 1763.

On 31st July, 1765, Roy was appointed, by Royal Warrant, Surveyor-General of Coasts and Engineer for making and directing Military Surveys in Great Britain, in addition to his appointment as D.Q.M.G. The wording of the warrant is that he was appointed "to inspect, survey and make Reports from time to time of the state of the Coasts and Districts of the Country adjacent to the Coasts of this Kingdom and the Islands thereunto belonging"; this is addressed to the Master-General of the Ordnance, who is to pay Roy an allowance of twenty shillings a day for these duties. The payment continued until Roy's death.*

Although the "Surveys" referred to in the warrant probably implied no more than inspections and investigations, still, Roy did, as a fact, from this time until his death, except for the period of the American War, occupy himself with map-making whenever the occasion permitted, and did not cease to advocate the formal establishment of a National Survey.

The outline of his subsequent career is briefly:—In 1767 he was elected a Fellow of the Royal Society; in 1768 he visited Gibraltar and reported on the defences; in 1783 he was a member of the Committee on the defence of Chatham, and was appointed a member of the board on Fortifications presided over by the Duke of Richmond, Master-General of the Ordnance; in 1778 he read a paper before the Royal Society on *Rules for Measuring Heights with a Barometer*; in 1783 he commenced the triangulation between London and Dover, and in 1784 he undertook the measurement of the base on Hounslow Heath. He was, in 1785, awarded the Copley medal of the Royal Society for this work.

In 1787 he read a paper before that Society on *The Relative Situation of the Royal Observatories of Greenwich and Paris*. On 23rd September, 1787, he met the French Commissioners at Dover; in 1789 his health began to fail and he went to Lisbon for the winter. He died suddenly in his house in Argyll Street, London, in July, 1790, whilst he was correcting the proof sheets of his paper for the Royal Society, entitled *An Account of the Trigonometrical Operations by which the Distance between the Meridians of the Royal Observatories of Greenwich and Paris has been Determined*. The manuscript of his great work, *The Military Antiquities of the Romans in North Britain*, was left ready for printing.

* See *General William Roy and his Military Antiquities of the Romans in North Britain*. George Macdonald Esq., C.B., F.S.A., LL.D., Oxford. Printed for the Society of Antiquaries, London.

The Society of Antiquaries published this, in 1793, in a splendid folio.

Roy's Letters from the Colby Collection.—The earliest letter in this collection is dated 1771. On the 26th October, 1771, Roy, writing probably to Dr. James Lind, says:—

DEAR SIR,

I fear from the unfavourableness of the weather, or some other cause, our operations on Calton hill on Thursday last are not what they ought to have been.—I don't know whether you have already made any calculations from them. Mine were done in a very great hurry and therefore I may have committed some mistake. However, you will no doubt observe, that in the triangle comprehended between the Observatory, Arthur Seat and the Calton hill, all of whose angles were taken, the sum exceeds by some five minutes and some seconds, 180 degrees. . . . The angle taken with my Quadrant on the Calton hill, comprehended between Arthur Seat and Kirk Newtown I found to be $113^{\circ} 35' 23''$. . . if an error so great is really made there it must have arisen from some motion in the Quadrant . . . from having only one Telescope. . . .

I am just going over to Sir Wm. Erskine's in Fife. I mean to return on Monday evening and before I go south will have the pleasure of seeing you. In the meantime I am with great regard,

Dear Sir,

Your most obedt. humble servant,

W. Roy.

It is not quite certain what kind of a quadrant was used by Roy, but the fact that he used one is interesting. It will be noted that he states that the instrument had only one telescope. The writer has consulted Mr. R. T. Gunther on the subject. Mr. Gunther is a high authority on old instruments, and his book on *Early Science in Oxford* may be studied with profit by all who are interested in such matters. In Rees' *Encyclopædia* of 1789, a surveyor's quadrant is described; this consisted of a quadrantal board with fixed slot-sights along one margin, and a movable radial alidade, also with slotted sights. The instrument was fixed in the horizontal plane by a ball-and-socket joint on a tripod. There was a diagonal scale for reading by. Roy may have used such a quadrant and may have substituted a telescope for one of the slotted sights.

In the next letter which has been preserved, after some grumbling on Roy's part with regard to the negligence of the Post Office, he refers to the observations which were being carried out (1774-76) by Maskelyne, the Astronomer Royal, to determine the attraction of a mountain of known mass and from this to infer the mean density of the earth. In Maskelyne's words, there were three operations to be performed: "(1) To find by celestial observations the apparent difference of latitude between two stations, chosen on the north and south sides of the hill. (2) To find the distance between the parallels

of latitude. (3) To determine the figure and dimensions of the hill." The hill selected was Schiehallien in Perthshire, now spelt Schichallion, the Gaelic form being Sith-chaillionn, *i.e.*, the Hill of the Caledonians.

Mr. Charles Hutton, F.R.S., who computed the results, obtained 5'0 as the density of the Earth, the present accepted value being 5'527. It was Hutton who first, at least in this country, invented contours. His Schiehallien calculations were published in the *Philosophical Transactions* of 1778, and he there says that he "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude"; by so doing he "obtained a great number of irregular polygons lying within, and at some distance from each other, and bearing a considerable resemblance to each other";—not the first time that a purely scientific investigation has resulted in a valuable practical discovery.

From William Roy.

Lanark, 26th July, 1774.

DEAR SIR,

. . . . Tho' I had left written directions in the Post Office at Edinburgh with respect to the forwarding of my letters, yet by the most astonishing negligence of the people there, I have only received about half my newspapers and very few letters. This appeared to me so strange that I have wrote to London to inform the Secretary of the General Post Office there of the matter. . . . I must therefore beg, My Dear Sir, that you would be so good as to release my letters in the Coffee House, indemnifying the people there. . . .

My intentions were, when I had the pleasure to see you, to return from Shihallan by the way of Edinburgh. . . . I took my leave of Maskelyne on the 15th, but I did not quit Strath Tay till the 18th, having some observations Geometrical as well as Barometrical to make on the neighbouring Mountains.

I am glad to hear that the Sector is at last adjusted. . . . The ground for the Base was so very unfavourable . . . that I advised Mr. Maskelyne to level and measure quite across it between the two stations. Ramsden's Barometers do wonderfully well, that is to say, they are uniformly consistent in their own results; though the rule for ascertaining heights by De Luc's method is defective.

In those days, and, indeed, until sixty years later, geodesists were in doubt as to what datum should be used for the measurement of heights. The conception of a sea-surface swinging up and down from a mean position had not been properly grasped. In consequence, we find Roy, in the following letter, taking "high water neap tide" as his datum surface.

In this letter, also, he writes about his barometer observations. It is remarkable how much time he devoted to this subject, which recurs again and again in his correspondence.

William Roy to Dr. Jas. Lind, Princes Street, New Town, Edinburgh.

Lanark, 5th September, 1774.

. . . I carried one of my Barometers to Glasgow on the 29th, leaving the other here. By three excellent corresponding observations, which differ from each other but a few feet, the station of my Barometer here is above the level of high water Neap Tide (which I take to be the mean height of the Sea) at Glasgow New Bridge 663½ feet. . . .

I have had another long letter from Maskelyne, who is now on the north side of the Hill (Schiehallien); nothing is yet fixed with respect to the distance of his two stations. He wants my Telescopic Spirit Level, which I shall endeavour to convey to Perth for his use when I arrive in Town; or I may perhaps send it to your care this week to be forwarded there.

On the 2nd June, 1775, he writes:

There are no accounts as yet from Captain Cook, neither do I hear a single word of Mr. Banks [President of the Royal Society] going any voyage to distant parts of the world. Tho' this morning he sets sail with Lord Sandwich to see the different Dockyards, on which trip he will be absent five or six weeks. . . .

I have been engaged for some time past in making experiments on the expansion of the Mercury, which I have after much plague and trouble ascertained at last. It is progressive and arithmetical. If I can get the paper ready in time it will be given to the R.S., before the Recess; if not, I must put it off until winter.

And on the 15th June:

. . . I have now and then found a degree of superior heat at the Top of St. Paul's, compared with that in the Churchyard. The same happened at Hampstead the other day, when compared with the Temperature in the yard of my house. The smook might occasion that at St. Paul's, I know not the reason of the last.

Do be so good as try thermometers in the Sunshine, free of reflected heat from walls, and also in the shade. Passing clouds make a very considerable difference, as I found the other day at Hampstead, the difference being 5° or 6°—tho' that in the shade continued unaltered. . . .

American affairs look muddy; we may possibly have something else to do than observe Barometers. . . .

American affairs got "muddier." Already, in fact, we were at war with the Colonies, which formally declared their independence on the 4th July, 1776. We were at war with the French in 1778, with Spain in 1779, and with Holland in 1781, in which year the American war came to an end by the surrender of Yorktown to the American and French forces.

During these years Roy appears to have been occupied with headquarter duties in London, but in exactly what capacity is not known. At the outbreak of war in 1775 he was a Lieut.-Colonel in

the Army and a Captain of Engineers. He held the appointment of D.Q.M.G., and was still in receipt of his special pay as Inspector of the Coasts and the Country adjacent thereto, so perhaps it was his business to arrange for local defence schemes. On the 7th November, 1775, writing from London, he says that he is "extremely busy":—

You will be surprised that I have been so long in acknowledging the Receipt of your obliging favour of the 28th September. The truth of the matter is plainly this that, having been for some time past extremely busy, I could not find time to go to the Mitre to meet any of the R.S. to enquire about Mr. Glennie's paper. . . .

I return you many thanks for the drawings of the antient entrenchments you have been so good as say you would permit me to copy.—I will do it with a great deal of pleasure, and the originals shall be carefully returned. I have never seen any one of the pieces you mentioned. The entrenchment at Lornly (for it is not a Camp) I saw a bad plan of, no way satisfactory, perhaps yours may be better.—I had not, when last in Scotland, time to go to see the work itself. Neither have I ever been at Barry Castle, tho' I have often observed it at a distance. . . . The height of Snowden above the sea is 3,568 feet; the vertical distance of the Barometers, the lowermost being on Carnarvon Quay, was 3,555. . . .

Roy's determination of the height of Snowden was remarkably good; the accepted modern value being 3,560 feet above mean sea-level.

His expression of thanks for "the drawings of the antient entrenchments" shows that even during this busy time in London he still retained the interest in archæology which he first showed in the early days of the map of Scotland. There are, indeed, many who think of Roy chiefly as an archæologist, and remember his name rather as the author of the *Military Antiquities* than as the founder of the Ordnance Survey. Mr. Macdonald's admirable study, already quoted, gives a very clear account of Roy's activities in this field of learning and of the writing of the *Military Antiquities* and construction of the plates, which now constitute its chief value. Mr. Macdonald shows that the manuscript copy of the book was probably presented by Roy to the King's Library before September, 1774.

The American war put an end, for a time, to all Roy's schemes for the systematic mapping of the British Isles. The few letters of this period that remain are full of the war. On the 13th January 1776, he writes:

. . . You see then how matters stand; we are no doubt to have a Body of 17,000 Foreign Troops in America next Campaign, I cannot tell whether any more medical assistance will be necessary, as it has been understood that the lesser Hospital going now out would afterwards be sent to Canada.—The great Hospital still to remain on the coast of the Atlantick. . . .

It is alleged, how truly I cannot say, that Lord S——ch is not so well at C——t as heretofore, owing to his supporting Admiral Greaves, who by all accounts, has behaved with great pusillanimity in his Command.

And on the 22nd February :

There are authentick good news just arrived in 18 days from Boston. Montgomery had assaulted Quebeck in which he with about 90 of his men were killed. Arnold is wounded and taken prisoner with about 300 more. The remainder have retreated to Montreal. We have therefore reason to hope that Quebeck will be safe for the winter, and that now the Succours will arrive in sufficient time to secure it in the spring.

Peace was not signed until 1783, and meanwhile all large survey schemes were necessarily put aside; British official surveys, were, however, about to undergo a change. We are getting to the end of compass sketches and the occasional use of quadrants. The state of mapping at home has its parallel in India. There, Major James Rennell of the Bengal Engineers, the first "Surveyor-General of the East India Company's dominions in Bengal," carried out his surveys with "compass and chain, supplemented by a Hadley's Quadrant for the determination of latitude."* Rennell's work is excellent of its kind, and is intermediate in accuracy between Watson's map of Scotland and Roy's later surveys.

Roy and Rennell.—The great surveys of the British Isles and of India have, from time to time, throughout their history, reacted favourably on each other, and it may be of interest to note the rough similarity that may be traced in the careers of Roy and Rennell. Both began their official lives outside the Army, Roy in the Post Office, Rennell in the Navy; both became Engineer Officers; both were elected Fellows of the Royal Society, and both received the Copley Medal from that Society; both Roy and Rennell felt a deep interest in history and archæology, shown in Roy's case by his *Military Antiquities of the Romans in North Britain*, a work which is still consulted for its plans, and in Rennell's case by his *Geography of Herodotus*, which a high authority pronounces as still of value; both were present at various military actions against the French; and Roy was the founder of the Ordnance Survey and Rennell of the Survey of India.

They must have known each other well. In 1779 Rennell, after returning from India, took a house in Charles Street, Cavendish Square; Roy was then permanently in London, in Argyll Street. Rennell was elected into the Royal Society in 1781, of which Society Roy had been a Fellow for fourteen years. Shortly

* *The Journals of Major James Rennell* (1764-67). Edited by T. H. D. La Touche. Calcutta, 1910.

before Roy's death he submitted to the Court of Directors of the East India Company some proposals for a trigonometrical survey of India, and Rennell supported these proposals.

The Surveys of France.—In 1783, at the end of the war, the surveys of France, both geodetic and topographic, were in a more advanced state than those of the British Isles; and, as the next impetus towards the formation of a national survey in this country came from France, we may, for a moment, glance at the state of affairs across the Channel.

In 1669–70 the Abbé Picard had carried out the first triangulation executed on the soil of France, using the method first adopted by Willebrord Snell in Holland in 1617. Picard's Triangulation consisted of a meridian chain from Paris to Amiens, and his object was to determine the dimensions of the earth. The radius of the earth so determined was used by Newton in 1682 to verify the theory of universal gravitation. Between 1683 and 1718 the two elder Cassinis, father and son, prolonged the chain to Dunkerque on the north, and southward to Collioure.*

The third Cassini, known as Cassini de Thury, with La Caille, revised the arc, which is generally known as the Meridian of France. The revision was carried out in 1739–40. This Cassini began, in 1744, the construction of a topographical map of France, based, no doubt, on triangulation where available. As it is easy to get confused with the dates of the four Cassinis, it may be noted that Cassini de Thury was born in 1714 and died in 1784.

The Surveys of Great Britain in 1783.—At the time of the Peace of 1783 there was in Great Britain no systematic triangulation, if we except the little, rough work that Roy himself had carried out in Scotland. Although the plane-table, in practically its modern form, had been known for at least two hundred years†, it appears that all the official sketches and reconnaissances were executed with the magnetic compass, and the order of accuracy was just that of a military compass sketch. Roy's intention to stiffen up Watson's map of Scotland, with a trigonometrical framework, had never been carried into effect. His efforts to establish a national survey department had been put aside, as a consequence, first, of the Seven Years' War, and later of the war with America. The maps of this country were due to private effort and were inferior in accuracy to those produced by Major Rennell in Bengal. Neither in geodesy nor in topography had our great-grandfathers any reason to be content with the state of affairs at home. But this state of affairs was about to be changed.

* *Revue Scientifique*. Article, *La Méridienne de France*, by Colonel Perrier. 8th September, 1923.

† *Early Science in Oxford*. R. T. Günther. Vol. I., p. 372.

II. THE BEGINNING OF ACCURATE SURVEYS. 1783-1790.

Scheme for a General Survey.—In the *Philosophical Transactions* of the Royal Society for the year 1785, Roy writes an *Account of the Measurement of a Base on Hounslow Heath*, and in the introduction to this account he remarks that, if a country has not actually been surveyed, or is but little known, a state of warfare generally produces the first improvements in its geography. He goes on to say that, “on the conclusion of the peace of 1763 it came for the first time under the consideration of Government to make a general survey of the whole island at public cost. Towards the execution of this work, whereof the direction was to have been committed to my charge, the map of Scotland was to have been made subservient, by extending the great triangles quite to the North extremity of the island, and filling them in from the original map.” He then points out that the American war put back this scheme. He continues, “in the course of my ordinary employments, wherein the best opportunities have offered of acquiring a thorough knowledge of the country, I have not failed to observe, at least in a general way, such situations as seemed to be the best adapted for the measurement of the bases that would be necessary for the formation of the great triangles.”

After the peace of 1783 official business detained him in or near London the whole of that summer. He took the opportunity, “for my own private amusement,” to measure a base about a mile-and-a-half long across the fields between “the Jew’s-Harp near Marybone and Black Lane near Pancras ; as a foundation for a series of triangles, . . . for determining the most remarkable steeples and other places in and about the Capital.”

He was engaged in making some computations for the purpose when he learnt of an important scheme for the execution of a triangulation to connect the observatories of Greenwich and Paris. The history of this scheme deserves to be put on record in some detail, for here we have the origin of accurate mapping in the British Isles.

The Third Cassini.—The third Cassini, Cassini de Thury (1714-1784) came of a line of astronomers and geodesists. He was a genuine

enthusiast in matters geodetical, and we may picture him as having the same driving force as Gill, in later times. In the year 1783 he wrote a "Mémoire," which was transmitted to Mr. Fox by the French Ambassador, Count d'Adhémar. The British Government referred the matter to the President of the Royal Society. There is a copy of the "Mémoire" preserved by that Society, and that copy has a docket on it, "From Ct. d'Adhémar, 7 oct. 1783"; but the "Mémoire" was not printed in *Philosophical Transactions* until 1787. The following is the text of it:—

Cassini's Mémoire.—*Sur la jonction de Douvres à Londres. Par M. Cassini de Thury, Directeur de l'Observatoire Royal; de la Société Royale de Londres, etc.*

"Il est intéressant pour le progrès de l'astronomie que l'on connaisse exactement la différence de longitude et de latitude entre les deux plus fameux observatoires de l'Europe; et quoique les observations astronomiques faites depuis un siècle offrent un moyen assez exact pour parvenir à cette recherche, il paraît cependant que l'on n'est point d'accord sur la longitude de Greenwich à onze seconds près, et sur la latitude à quinze seconds.

L'on a reconnu par les opérations trigonométriques exécutées en France, au Nord, et au Pérou, que sur l'étendue d'un degré du méridien ou de 57 mille toises, l'on se trompait à peine de dix toises, ce qui a été prouvé par des bases mesurées à l'extrémité des suites de triangles; ainsi sur la distance de Douvres à Londres, qui est de 49,800 toises ou environ, on ne pourrait se tromper de 120 toises, qui repondent à onze seconds en longitude.

M. Cassini a déjà publié, dans le livre de *La Méridienne Vérifiée*, les opérations par lesquelles l'on a déterminé la distance de Calais à la grosse tour de Douvres de 18,241 toises par un premier triangle, et de 18,243 toises par un second triangle; on aurait cette distance avec une plus grande exactitude en observant les angles conclus à Douvres, qui sont fort aigus. M. Cassini a découvert des côtes de France plusieurs objets sur les côtes d'Angleterre, qui seront visibles de la tour de Douvres; et sur cette première base on établirait une suite de quelques triangles jusqu'à Londres, dont le nombre et la grandeur dépendent de l'exposition des objets compris dans la direction de Douvres à Londres.

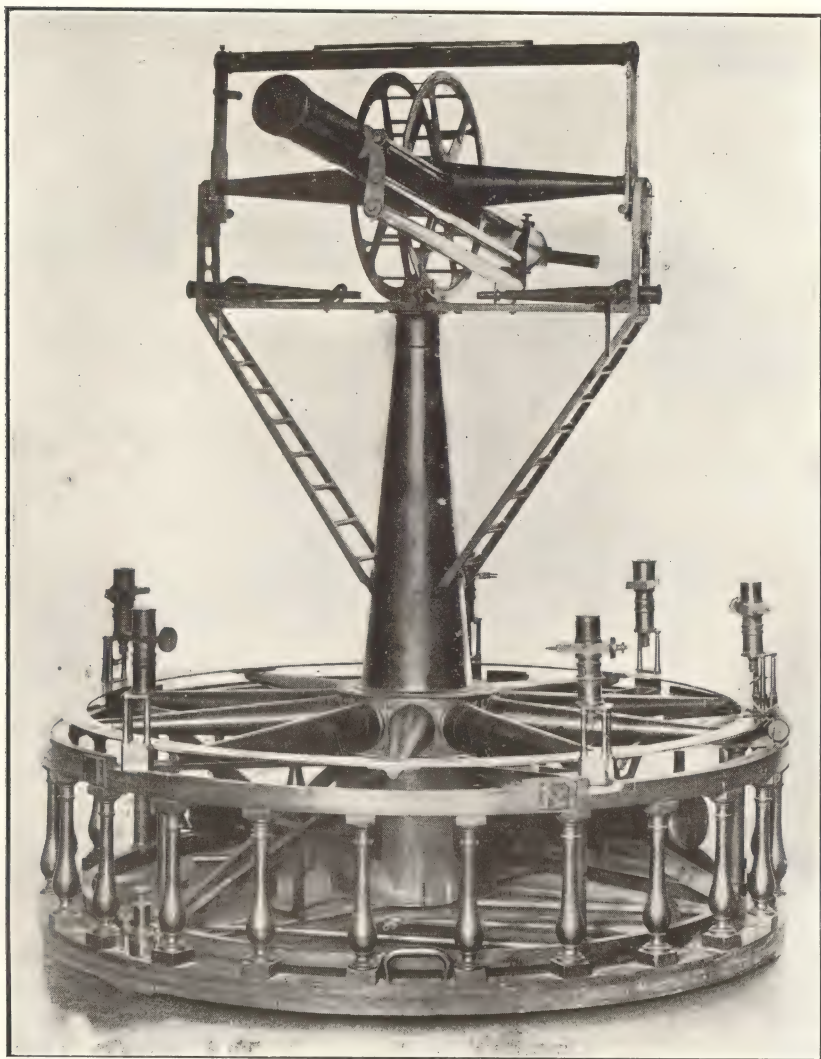
M. Cassini ne doute point que ce projet ne soit agréé d'un Souverain qui aime les sciences, qui, non content des découvertes du célèbre Cook, vient d'ordonner un second voyage autour du monde, et que la Société Royale ne charge un de ses membres de l'exécution; et dans le cas où ses occupations l'empêcheraient de s'y livrer, qu'elle ne permît à M. Cassini de s'en charger. L'honneur qu'elle lui a fait de l'associer à un corps aussi respectable serait un titre pour lui accorder sa confiance. M. Cassini a profité du voyage du Roi en Flandres en 1748 pour joindre les triangles de la méridienne à ceux de Snellius en Hollande; en 1762 il a prolongé la perpendiculaire de Paris jusqu'à Vienne en Autriche. La branche qui s'étendra jusqu'à Londres sera la troisième, et formera la jonction des deux plus belles villes de l'Europe.

Effect of the Mémoire.—This communication was made at a very opportune time, but it must be confessed that its first paragraph is tactless to a remarkable degree. It states roundly that the latitude of Greenwich was in doubt by some fifteen seconds, and that in order to determine the correct value it was desirable to connect Greenwich geodetically with Paris! To such a statement objection was naturally taken by the Astronomer Royal, Dr. Maskelyne, who wrote an answer which was published in *Philosophical Transactions* immediately after the Mémoire—but not until 1787. Maskelyne says that “the latitude of the Royal Observatory at Greenwich is firmly established by Dr. Bradley’s observations and my own at $51^{\circ} 28' 40''$, probably without the error of a single second.”

He further says: “The extensive geometrical operations recommended by the late M. Cassini de Thury [Cassini died in 1784], and commenced under the direction of Major-General Roy, F.R.S., by his exact measures of a base on Hounslow Heath, may also, when completed, determine the difference of meridians of Greenwich and Paris to great exactness. But they do not seem to me likely to throw any new light on the difference of latitude of the two observatories, because the uncertainty we are still under about the true figure and dimensions of the Earth, and the irregular attractions . . . would prevent us from drawing any accurate conclusions.”

There can be no doubt that Maskelyne was entirely right, and that Cassini was mistaken when he advocated the execution of a geodetic connection between Greenwich and Paris, in order to ascertain the latitude of the former observatory. But he may well be forgiven, for his memorandum was used as a most effective lever by those who desired to put the surveys of this country on a better footing. King George III., to whom the memorandum was submitted, was anxious to oblige the French; the Royal Society was willing to assist in the project to ascertain the difference of the longitude of the two observatories; and Roy, to whom the execution of the scheme was to be confided, looked upon it chiefly as a means of providing an accurate framework for map-making, and stated that the chief and ultimate object “has always been considered of a still more important nature [than the mere joining of the observatories], namely, the laying the foundation of a general survey of the British Islands.” There were, thus, several motives at work, political, scientific and practical, and all contributed to the adoption of the proposal.

The King himself took a personal interest in the matter and defrayed the cost of the necessary instruments. The Royal Society undertook the general direction of the work; and the services of Major-General Roy were lent by the military authorities. It was decided to observe the angles with “a large circular instrument,”



Present state (1924) of Ramsden's 3-ft. Theodolite.
Presented by King George III. to the Royal Society. In use by the Ordnance
Survey from 1787 to 1853.

or theodolite, and Jesse Ramsden, the finest instrument-maker of the time, was entrusted with its construction.

Ramsden.—According to the *Dictionary of National Biography*, Jesse Ramsden was born in 1735, his father being an inn-keeper at Halifax, Yorkshire. He was apprenticed to Burton, a mathematical instrument-maker in the Strand, in 1758. In 1765 he married the daughter of John Dollond, the optician. He was a man of marked ability, and the “artist’s genius disdained time restrictions.” Later on we shall see how great a trial this dilatory artist was to Roy. “On one occasion he attended at Buckingham House precisely as he supposed at the time named in the royal mandate. The King remarked that he was punctual as to the day and hour, while late by a whole year.” In 1777 the Commissioners of Longitude published the description of his *Engine for dividing Mathematical Instruments*. He made large numbers of the finest astronomical instruments of his day. “The demand from all parts of Europe for his incomparable instruments was greater than could be satisfied by the constant labour of 60 workmen.” Delambre styled him “*le plus grand de tous les artistes*.” He was elected a Fellow of the Royal Society in 1783, and in 1795 he received the Copley medal. He died in the year 1800, leaving behind him the memory of an upright, kindly man of genius, absorbed in his work. His portrait by Robert Hume is in the rooms of the Royal Society.

The Great Circular Instrument.—The great three-foot theodolite, which was presented by the King to the Royal Society, (no doubt after discussions as to its design between Sir Joseph Banks, Ramsden, Roy and Maskelyne), was apparently ordered in August, 1784. It is the father of accurate theodolites. The horizontal circle of brass, 3 ft. in diameter, is divided by dots into spaces of ten minutes; there were originally two micrometer microscopes for reading this circle; angles can be read to tenths of seconds. This was the first instrument capable of detecting spherical excess. It weighs about 200 pounds, and was carried when travelling in a four-wheeled spring van. It is now preserved at the Ordnance Survey Office at Southampton. It is known as the 3-ft. *Theodolite R.S.*, to distinguish it from a similar instrument, ordered subsequently by the Board of Ordnance, and known as 3-ft. *Theodolite B.O.* The former instrument was first used in 1787 and was last used in 1853; having thus been in use for 66 years.

Hounslow Heath Base.—Roy says that “a generous and beneficent monarch, whose knowledge and love of the sciences are sufficiently evinced by the protection which He constantly affords them, and under whose auspices they are seen daily to flourish, soon supplied the funds that were judged necessary.” Having thus the goodwill of the highest authorities in the State and in the scientific world, it was not long before a beginning was made. Roy suggested that

a base should be measured on Hounslow Heath, and on the 16th April, 1784, a day much to be remembered, the President of the Royal Society, General Roy, Dr. Blagden and Mr. Cavendish, began the examination of the ground at King's Arbour and finished at Hampton Poor-House, near the side of Bushey Park, a distance of some five miles. "Chiefly with a view to the more effectual execution of the work, it was judged to be a right measure to obtain and employ soldiers, instead of country labourers, in tracing the base, clearing the ground, and assisting in the subsequent operations. They would furnish the necessary centinels for guarding the apparatus. . . . Accordingly a party of the 12th regiment of foot, consisting of a serjeant, corporal and 10 men, was ordered to march from Windsor to Hounslow Heath, where they encamped on the 26th May."

Volunteers, for assisting in the preliminary measurement, were Lieut.-Colonel Calderwood, F.R.S., of H.M. Horse Guards, Lieut.-Colonel Pringle of the Corps of Engineers, Mr. Lloyd, F.R.S., and Ensign Reynolds, 34th Regiment, who also made a local plan.

It had originally been intended, in accordance with what was then the almost universal custom on the Continent, to measure the base with deal rods, and a set of them was prepared for the purpose. The greatest care was taken in the construction of these rods, but experience showed that variations in humidity caused considerable changes in their lengths, and, after exhaustive trials, the idea of using wooden rods was abandoned.

At the outset of the operations a steel chain had been ordered from Ramsden, "the best that he could make." It is not quite clear why this chain was ordered, for Roy states that it was not intended to accept the result of measurement by its means; he also says that the chain, after some alterations, may be "advantageously applied to ordinary measurement on the surface of the earth." However, the chain was made and used in the rough measurement of the base, which was begun on the 16th June and completed on the 22nd.

The definitive measurement of the base was carried out by most unusual means, namely, by glass tubes. The idea of using these was due to Lieut.-Colonel Calderwood, who "was accordingly requested to make the trial at the glasshouse, as soon as possible after his return to town. Next day he succeeded in getting a fine tube drawn, eighteen feet long and about one inch in diameter." Several tubes were made, one being no less than twenty-six feet long; and Ramsden was entrusted with the work of making them suitable for use in measurement. Very full details are to be found in *Philosophical Transactions*, or in Volume I of the *Account of the Trigonometrical Survey of England and Wales*.

The final measurement was commenced on the 17th August, 1784,

and was finished on the 30th of the same month. The work excited very general interest. On Saturday, the 21st of August, "about noon, his Majesty deigned to honour the operation by his presence, for the space of two hours, entering very minutely into the work of conducting it, which met with his gracious approbation." The gentlemen who assisted in the last day's operation were "Captain Bisset, Mr. Greville, Sir William Hamilton, Mr. Lloyd and Dr. Usher, Professor of Astronomy in the College of Dublin."

"The respectable and very worthy President of the Royal Society, ever zealous in the cause of science," repeatedly visited the Heath, and in the final stages of the measurement gave his attendance from morning to night "and with that liberality of mind which distinguishes all his actions, ordered his tents to be continually pitched near at hand, where his immediate guests, and the numerous visitors whom curiosity drew to the spot, met with the most hospitable supply of every necessary, and even elegant refreshment."

The length of this base, after applying corrections for temperature and reduction of sea-level, was 27,404'01 ft.

The base was re-measured in 1791, after Roy's death, by Lieut.-Colonel Edward Williams, then Director of the Survey. This time the measurement was carried out with two new chains made by Ramsden. The new value of the base was found to be 27,404'32 ft.

The mean of the two results was thereafter taken as the true length, *viz.*, 27,404'2 ft.

Standard of Length.—With regard to the standard of length, Roy states that "at the sale of the late ingenious optician Mr. James Short, I purchased a finely divided brass scale, of the length of 42 inches," reading by verniers to the thousandth of an inch. The scale originally belonged to Graham, the celebrated watch-maker"; has the name of Jonathan Sisson engraved upon it; but is known to have been divided by the late Mr. Bird, who then worked with Sisson. (Bird, an instrument-maker, as deservedly celebrated as Ramsden, died in 1776.) This brass scale was compared with the scale belonging to the Royal Society, which had engraved upon it the length of the standard yard from the Tower, that from the Exchequer, and also the French half-toise. This R.S. scale had been made by Sisson, and a duplicate had been sent to Paris for use by the Royal Academy of Sciences.

Instrument Makers.—A recital of the names of these great instrument-makers calls to mind the immense debt which all explorers and surveyors owe to them and to their successors. English instrument-makers were, and are still, for most purposes, the most competent and ingenious in the world. Too often it is forgotten how greatly the success of a geodetic operation depends upon the exquisitely fine construction of the instruments used; too often the observer, whose work, though tedious, is to some extent mechanical,

is apt to attribute to himself a success which is largely due to the maker of his instruments. Indeed, in this matter it is hard to say which of the trio deserves most credit: the mathematician who devises the theory, the laborious observer who accumulates the facts, or the instrument-maker, whose skill in design and minute accuracy of execution principally contributes to the reliability of the result. These old instrument-makers have had worthy British successors in Troughton, Simms, Cooke, Watts and others.

The Base Terminals.—In Roy's time the terminals were marked by wooden pipes, a foot in diameter, with a bore of four inches. In 1791 the wooden pipes were found in a very decayed state and were replaced by guns, placed vertically, muzzle upwards and carefully centred. The guns were selected at Woolwich, by order of the Master-General, and were sent to Hampton by water. Wooden plugs were fixed in the bores, with centre dots marked on them, and iron caps were screwed over the muzzles. These guns still remain in position (1924), the western gun being enclosed by a railing; but the plugs and caps have disappeared.

Roy, in the last communication made by him to the Royal Society—he was correcting the proofs when he died—spoke strongly of the desirability of making indestructible terminals. He said, “these should be low circular buildings, rising but a few feet above the surface of the Heath, composed of the hardest materials such as granite . . . they would resemble those basements of ancient crosses we often meet with. . . . In the interior of this little building, metal tablets would be inserted, containing the name of that much-beloved monarch in whose reign the operation was begun . . . the distance from one another, the angle of the base with the meridian, and also the magnetical variation.”

In 1926 we shall be able to commemorate the second centenary of Roy's birth. Perhaps the little circular buildings imagined by him might be built then. They would be appropriate memorials to the founder of the Survey.

Delays.—After the measurement of the base on Hounslow Heath the official records have little to chronicle for nearly three years. It was, in fact, impossible to get to work on the observation of the angles of the triangulation, which was to connect London with Paris, because Ramsden took all this time to construct the “great circular instrument.” Some useful work was, however, carried out by Lieut. Fiddes of the Engineers, who was permitted by the Duke of Richmond, Master-General of the Ordnance, to be employed, under General Roy, in making a very accurate plan of that part of Romney Marsh where the base of verification was to be measured. This was during the summers of 1786 and 1787.

Roy's Later Letters.—We can get some idea of Roy's own activities during this (to him) very trying period, from some of his later letters.

Thus, on the 10th September, 1786, we find him writing a letter, probably to Dr. Lind at Windsor, which shows that the King continued to take an interest in the work. The letter also shows how much Roy felt the delay caused by Ramsden's dilatory proceedings.

"Having left London yesterday afternoon, it was not till this morning that I received at this place your letter of the 9th; and it gives me great concern that, owing to this accidental circumstance, I could not have the Honour of obeying the Commands therein signified. . . . I could easily have transported myself to Hampstead from whence I should certainly have seen the lights exhibited there. The truth is that my presence was necessary to forward some parts of the apparatus for the Triangular operation, which, notwithstanding every effort of mine, I fear we shall not be able to begin this Season.

"It will be yet some days before Ramsden can possibly finish the Division and after that the semicircle for the uppermost telescope is to divide, the levels to adjust, and a number of other small things to do, all of which require time, and it will certainly render it too late in the season to think of taking men into the Field to encamp. . . . It is hard upon me to have this operation hanging over my head for another year, without any fault of mine; But with such a man as Ramsden there is no help for it.

"The experiments formerly made with the White Lights were perfectly satisfactory with regard to the use that we may derive from them, particularly in taking the angles across the Channel between Kent and Piccardie. I nevertheless think that it may be proper to try them once more between Shooter's Hill Tower and Nettlebed Windmill, a distance of about 47 miles, by reciprocal observations. This I took the liberty to mention to H.M. . . . Even the preparations for this sort of experiment require time. . . . I will supply you with the angles for pointing the Telescopes at Windsor on the two extreme objects; as it is not unlikely that H.M. may choose to look out from thence."

And here are two more letters addressed to Dr. Lind:—

From William Roy (to Dr. Lind at Windsor).

Argyll Street, 8th March, 1787.

I wish you would be so good as to supply me, as nearly as you can, with the distance between the center of the Devil's Tower (which henceforth I shall call the Maiden Tower) and the Flagstaff of the Castle. . . .

The object I have in view is to shew how nearly the longitudes of places may be determined by means of Ramsden's Instrument; and in the Duplicate of my Paper (which will be read this day at the R. Society) prepared for H.M. I mean to give an example of the computations of the Longitude of the Tower of Flagstaff from Greenwich. . . .

From William Roy (to Dr. Lind, Windsor).

Argyll Street, 2nd July, 1787.

Although, when one has, unfortunately, to do with such a man as Ramsden, it is altogether impossible to answer for what may happen;

yet I hope we shall be able to try the Instrument in Hyde Park on Wednesday or Thursday next.

Perhaps H.M. may not like to have the Signal Staff on the Wardrobe Tower remain there for any length of time. If the Staff itself, Two Deals, and Four upright pieces are prepared, it may be put up any morning, and you can easily describe to the workmen entrusted with the execution in what manner they are to be joined together. . . . and if you are so good as to go up at that time you will be able to tell me how the trees on St. Anns Hill appear?

During the time of waiting, the selection of stations for the triangulation was completed and a diagram was submitted to the Royal Society. In the spring of 1787, Sir Joseph Banks, President of that Society, communicated, through the Secretary of State, with the French Academy of Sciences, in order that the French geodesists might be ready to co-operate with the British in observing the rays crossing the Channel. And all this time the necessary preparations were being completed for the erection of scaffolds and the showing of "white lights." The composition for these lights was burnt in a copper retainer. The light apparently did not last long.

The Duke of Richmond, Master-General of the Ordnance, gave every assistance, both in the preliminary operations and during the actual observations, by "furnishing an officer and a detachment of artillery-men for the work; ordering the laboratory at Woolwich to supply whatever fireworks might be wanted for signals; and temporary scaffolds to be erected at Greenwich Observatory, Shooter's Hill and Dover Castle, for the reception of the instrument."

In Roy's next letter there is an interesting reference to operations "westward of Windsor," showing that he always kept in mind, as the chief object in view, the triangulation of the whole country.

William Roy (To Dr. Lind, Windsor).

Argyll Street, June 23rd, 1787.

I always intended to apply to you for assistance, in any thing respecting the Signal proposed to be erected in the Center of the Platform of the Wardrobe Tower at Windsor. But I did not think it necessary to give any trouble of this sort, until we were just ready to begin.—At the instant that I write the Instrument is not finished. But Ramsden has been for some time past and at present is close at work upon it with every hand that he can employ. . . . I mean to adjust the line of collimation of the Transit Telescope, and see whether, by inversion to the Pole Star when it is stationary, it sweeps the vertical arches? . . .

When our observations have been made, the Staff, if H.M. shall please, may be removed; but the socket at Bottom should remain, as the point over which the Instrument is afterwards to be placed, when H.M. may please to order the operations to be continued to the westward of Windsor.

. . . You will no doubt come and see us at the Hampton end of the base where I mean to begin, and then I can show you our Flagstaffs.

Execution of the Triangulation.—At length the instrument was finished, 35 months after it was ordered, and was placed on the 31st July, 1787, at the station at the end of the Hounslow Heath base, near Hampton Poor House. It was agreed that the British and French observers should meet about the 20th September. Between 31st July and that date the triangulation was pushed forward, working from the Heath south-eastwards and, before the meeting with the French, ten stations, as far as Wrotham Hill inclusive, had been observed from.

From William Roy to (Dr. Lind at Windsor).

St. Ann's Hill, 17th August, 1787.

It has blown so hard all day long and still continues to do so, that we have not been able to make any observation.

 If you please, one of the Lights may be fired about a quarter before 8 o'clock. As there is so small a prospect of calm weather I think it will be useless to throw away more of them. Our other Lights will be fired as I mentioned in my last.—But Artillery men's watches may probably (be) as bad as my friend Bisset's was on a former occasion.

The French representatives were three distinguished members of the Academy of Sciences, Comte de Cassini (the fourth Cassini), Mechain and Le Gendre. They arrived at Dover on the 23rd of September, and the two parties amicably settled the details of the operation. "A great number of white lights, fitted for long distances, and several reverberatory lamps had been previously provided." The French party, accompanied by Dr. Blagden, left for Calais on the 25th. The trigonometrical connection was successfully accomplished by the 17th of October.

It now only remained to complete the gap between the coast of Kent and Wrotham Hill. The season was getting late and Roy speaks feelingly of the tempestuous weather. "Perched on the tops of high steeples, such as Lydd and Tenterden, . . . we sufficiently experienced that operations of this sort, where the most important observations could only be made at night, by means of the white lights, should never be undertaken in the latter season." The use of luminous signals agrees with modern practice. Some difficulty was found in observing to them, for the lights did not burn for long and sometimes two would show up at the same time, "from the irregularity of the rates of the watches of the artillery-men." Two stations in the chain had to be left to the next season.

The distance covered was only some eighty miles, but the country was not particularly easy to triangulate. The chain of stations was: Hounslow Heath base, St. Ann's Hill, Hanger Hill, Norwood, Greenwich Observatory, Shooter's Hill, Botley Hill, Wrotham Hill, Hollingbourne, Frant, Goudhurst, Tenterden, Fairlight, Lydd, Romney base, Allington, Paddlesworth, Folkestone and Dover

Castle. The distance between Greenwich and Dover is about 60 miles.

Base in Romney Marsh.—This base of verification was measured with Ramsden's hundred-feet steel chain in the autumn of 1787. Lieut. Fiddes of the Engineers was in charge of the work, and Roy says that "it was impossible for any person to fulfil the duties entrusted to him better than he did." Lieut. Bryce* of the Artillery, subsequently transferred to the Engineers, "an attentive officer and mathematician," was appointed to assist Lieut. Fiddes. We need not go into the details of this measurement. The base, as then measured, was 28,535·7 ft. long; as deduced from the Hounslow Heath base the value came out as 28,533·3 ft., a difference of 2·4 ft. or about 1 in 12,000. These values are given by Mudge. But Roy, in 1788, thought that the accordance was closer, for on the 7th February he writes to Dr. Lind :—

It will give you pleasure to be informed that our trigonometrical operation answers to a wonderful degree of exactness. The base in Romney Marsh, between 28,000 and 29,000 feet, deduced from that on Hounslow Heath, agrees with the measurement within less than a foot.

The actual discrepancy found between the measured and calculated lengths of the base in Romney Marsh appears to be due, almost entirely, to errors in the measurement of this base. It is stated that there are reasons to suppose that it was not measured as accurately as the Hounslow Heath base. The latter, when tested by the definitive nineteenth-century triangulation, has only an error of $\frac{1}{158000}$, or 2 inches in 5 miles. Moreover, Roy's angles, as tested by the triangular errors of the 16 fully observed triangles, are wonderfully good, the mean triangular error, independent of sign, being just over one second.

The agreement between the distances across the Channel, derived from the English and French triangulations respectively, was good. Thus, taking the distance from the station at Dover Castle to the spire of Notre Dame at Calais, using only the Hounslow Heath base to compute from,

The English value was 137,449 feet.

The French ,, ,, 137,442 ,,

The derived difference of longitude, Greenwich-Paris, was 2° 19' 51".

No angles observed by Roy are incorporated in the Great Triangulation as reduced by Clarke; in fact, there is only one eighteenth-century set of angles included, namely, those observed by Mudge at St. Ann's Hill in 1792. But Roy's work deserves all

* Afterwards Sir A. Bryce, Inspector-General of Fortifications.

praise. It was the first accurate triangulation carried out in this country and set a remarkably high standard ; it amply fulfilled its original scientific purpose ; it provided, for the first time, a thoroughly reliable framework for map making ; and it led directly to the formal founding of the Ordnance Survey.

Isaac Dalby.—Dalby was born in Gloucestershire in 1744, and after a struggling career, in which he always showed his preference for scientific occupations, he became, in 1751, mathematical master at the Naval School at Chelsea. In 1787 he was recommended by Ramsden to Roy. The latter, in describing the operations of that year, remarks, "it is proper that I should mention that Mr. Dalby, who had been recommended as an assistant, has acquitted himself throughout the whole perfectly to my satisfaction." In 1788 we find him making astronomical observations in the field. He contributed an addendum to Roy's *Account* of the Triangulation, which was published in *Philosophical Transactions* for 1790. He continued to be employed on the field work of the Survey until 1799. Captain Mudge writes, in the Introduction to Volume II of the *Account of the Trigonometrical Survey*: "I am to announce that Mr. Isaac Dalby, no longer able to endure the fatigues incident to the service, has retired from it ; and it would be a matter of injustice, if I were not to acknowledge the extent of his services, his unremitted labour, and attention."

Dalby was the author of a celebrated geodetic formula, known as Dalby's Theorem,* and was responsible for much of the mathematical work of the Survey in those early days. On leaving the Survey he became Professor of Mathematics at the Royal Military College, then at High Wycombe. He resigned this post in 1820 and died at Farnham in 1824. He was an original member of the Linnean Society.

Roy's Last Days.—Roy and his assistants completed the trigonometrical connection in 1788, and during the same year a considerable number of intersected and secondary points were observed in Kent and Middlesex, Roy having always in mind the mapping of the country. In his last paper he says, "the writer of this account cannot help considering it as being incumbent on him to recommend that the trigonometrical operation, so successfully begun, should certainly be continued, and gradually extended over the whole island. Compared with the greatness of the object, the annual

* If λ, λ' be the latitudes of two points on the surface of a spheroid, ω their difference of longitude, α, α' their reciprocal azimuths,

$$\tan \frac{\omega}{2} = \frac{\cos \frac{\lambda' - \lambda}{2}}{\sin \frac{\lambda' + \lambda}{2}} \cot \frac{\alpha' + \alpha}{2}.$$

expençe to the publick would be a mere trifle . . . The honour of the nation is concerned in having at least as good a map of this as there is of any other country."

In September, 1788, he returned to London in very indifferent health. In November, 1789, he went to Lisbon for the winter. In April, 1790, he returned to England and was engaged in correcting the proofs of his *Account of the Trigonometrical Operation for Philosophical Transactions*. He died suddenly in Argyll Street, in July, 1790, having corrected the proofs of all but the last three pages of this account.

"During the later years of his life the fame he had won as a geodesist rather tended to eclipse his reputation as an antiquary; and on the whole we may be certain that, if a choice had to be made, this is what he himself would have wished. By the faithful, however, he was still rightly regarded as the leading authority on Roman Scotland."*

Soldier, geodesist, antiquary, the Ordnance Survey has every reason to be proud of its founder. And may all Survey officers aim at the same reputation!

* *General William Roy and his Military Antiquities, etc.*, by George Macdonald, C.B., F.B.A., LL.D. Society of Antiquaries of London, 1917.



F.M. the Duke of Richmond, K.G., F.R.S., 1735—1806,
Master-General of the Ordnance, 1782—1795.

From a picture by Romney, reproduced by permission of His Grace the Duke of Richmond and Gordon, K.G.



III. THE SURVEY IS FORMALLY FOUNDED.

The Duke of Richmond.—If it is to General Roy that we owe the first conception of a National Survey, it is no less certain that it was the Duke of Richmond who made the scheme possible and created the department officially. Throughout the early records of the Survey numerous references will be found to the practical support given by the Duke to the geodetic operations which were, in those days, under the general control of the Royal Society ; and, when the proper time came, it was the Duke who took the initiative and converted what was, till then, mainly a scientific undertaking, into a National Survey. In the preface to the *Account of the Trigonometrical Operations*, by Captain Mudge and Mr. Dalby, it is stated that “ the design . . . had not, in its origin, that extensive application which has since attended the endeavours of his Grace the Duke of Richmond, with respect to subsequent trigonometrical operations.” In 1791 we find the Duke issuing instructions “ to be minute in our Survey of Sussex ” with a view to the construction of a map of that county. In 1794 he directed that the operations for that year should commence in Kent and be continued till that county was finished and then be carried over into Essex. Earlier General Roy stated that “ the Duke of Richmond, Master General of His Majesty’s Ordnance, had, in the most liberal manner possible, given every assistance to the operation (from that great department over which he presides with so much honour to himself and advantage to the public).” Lieut.-Colonel Edward Williams, the first official Director of the Survey, speaks of “ the liberal assistance which his Grace the Duke of Richmond had on all occasions given to this undertaking,” that is, to the early operations under the Royal Society. And Portlock, writing in 1853, stated that General Roy particularly acknowledged the attention that the Duke always paid to his representations, and that it was from the Duke that the idea of a National Survey received its earliest and most decided support. Portlock adds, “ Taking, then, into consideration the encouragement he conferred on this peculiar branch of the Ordnance service—asserting, by so doing, the claims of Ordnance officers to be looked upon as scientific men—the patience with which he investigated the now popular subject of national defence, and the personal attention he

bestowed on all the military departments of the Ordnance, including the Royal Military Academy, it may be justly said that the Duke of Richmond stands in the first rank of Masters-General of the Ordnance."

Charles Lennox, 3rd Duke of Richmond, was born in 1735, and succeeded to the title in 1750. He entered the Army, and distinguished himself at the Battle of Minden. After the peace he was appointed Ambassador to Paris (in 1765). On his return he took a large part in public life, embraced the cause of the American Colonies, and denounced the Ministerial policy. In December, 1775, he declared that the resistance of the colonists was "neither treason nor rebellion, but is perfectly justifiable in every possible political and moral sense." At this period King George III. entertained a strong personal dislike for the Duke, but after the close of the war they became friends; and a few years later the King said that "there was no man in his dominions by whom he had been so much offended, and no man to whom he was so much indebted, as the Duke of Richmond."*

He was appointed Captain in the 20th Regiment of Foot in 1753, and received the rapid promotion to be expected in those days in the case of a man of his position and ability. He was promoted to Major-General in 1761 and was made a Field-Marshal in 1796. He appears to have been particularly interested in two subjects which are dealt with by the Engineers of our Army, namely, fortification and surveys. In 1783, as Master-General of the Ordnance, he appointed General Roy a member of the Board on Fortifications, over which he himself presided. In the same year he nominated a special committee to consider the defences of Chatham. He was supported by Pitt in his proposals to remodel the fortifications of Portsmouth and Plymouth; but the House of Commons, alarmed at the probable expense, threw out these proposals, after a division which required the casting vote of the Speaker.

The existence of the Ordnance Survey is evidence as to his interest in surveying. Not only did he, during Roy's lifetime, give the most effective assistance, in this matter, to the Royal Society, of which Society he was a Fellow, but after Roy's death he took the decisive step of putting the Survey under the Board of Ordnance, and thereby established it as an official department. But for the Duke of Richmond the National Survey, if it had come into existence at all, would almost certainly have assumed a different and less efficient form; and it was a fortunate thing for the Survey, not only that it came under the Board of Ordnance, but that the Master-General was well acquainted with Roy and his work, and was able to preside over its destinies for the first few years.

* *Dictionary of National Biography.*

The Duke was a man of the widest interests ; fond of country life and sports, a patron of literature, science and the fine arts, a soldier of distinction, and a statesman of far-seeing views. He was a great friend of Romney ; Goodwood contains many examples of this artist's work, painted to order of the Duke. He was much interested in the work of " that able artist Mr. Ramsden"—an artist in brass and glass. Indeed there were few aspects of life in which he was not interested. Burke is said to have reproached him with spreading his talents over too wide a field. It does not appear, however, that the objects of his interest suffered in consequence. Amongst them may be mentioned racing ; he made the famous racecourse at Goodwood. In the *Sporting Magazine* for April, 1801, may be found the following notice : " The new racecourse on the Harroway, near Goodwood, the seat of his Grace the Duke of Richmond, is now completely formed for sport, and much admired by acknowledged amateurs of the Turf."

Many stories are told of his fondness for hunting and of his autocratic, if kindly, ways as Master. " Such was his Grace's desire to give fair play to a good fox, that once, after a capital run, the fox having sought refuge upon the porch of Waltham Church, which was covered with ivy, but not sufficiently to conceal his brush from the view of his pursuers, who with their whips were trying to dislodge him, the noble Master rode up in great haste and anger, asking them to desist, and exclaiming, " Why do you want to murder such a fox ? leave him alone. He has shown you a good day's sport, and if left will show you another."*

The Duke was appointed Master-General of the Ordnance in March, 1782, and retired from that position in February, 1795, being succeeded by Lord Cornwallis. The appointment is not to be confused with the less important post which nowadays carries the same name. In those days the Honourable Board of Ordnance was a great department, possessing extended powers. Its history dated back to the middle of the fifteenth century, and for four hundred years it maintained a tradition of independence and authority. The Master-General was responsible for the Artillery and Engineers of the Army, for fortifications and armaments, and all things therewith connected ; he was one of the King's principal advisers, and was at all times a military power to be reckoned with. In later years the position was held by the Duke of Wellington. The Duke of Richmond's tenure of the appointment covered those ten years, a brief breathing space, between the war with the American Colonies and their allies, and the war with revolutionary France, extending on into the latter. After his retirement he lived almost entirely at

* *Records and Reminiscences of Goodwood and the Dukes of Richm.ord.* John Kent. Sampson Low, Marston & Co., Ltd. 1896.

Goodwood, where he died on the 29th December, 1806. He was buried in the Cathedral Church of Chichester.

The Ordnance Survey, which preserves in its name the history of its creation by the Honourable Board, and is the last surviving branch of that ancient institution, is always bound to keep in pious remembrance the name of the distinguished Master-General who founded it.

The word "Ordnance."—The word "ordnance" is a syncopated variant of "ordinance," which is itself derived from the old French word "ordenance" (a regulation and an arranging in order). In the seventeenth century the word "ordnance" came to be exclusively applied to artillery and engineer personnel and material, and the services relating to these.* In the early days of the Survey the expression "Ordnance Survey" was not used, at least officially. Thus, in 1811 was published the third volume of the account of the *Trigonometrical Survey carried on by order of the Master-General of His Majesty's Ordnance*, and the work is sometimes alluded to as the British Survey, or the British Trigonometrical Survey, or the General Survey of Great Britain. In a letter dated 1817, from the Master-General of the Ordnance to the Lord Advocate of Scotland, the expression "Ordnance Map" is used. The first use of the term "Ordnance Survey" that can be found is in a minute dated 1820, when the "eighth part" of the *Ordnance Survey* was presented to the Duke of Wellington, then Master-General; in this sense it meant the map itself. In 1827 the official *Instructions for the Interior Survey of Ireland* are stated to have been lithographed at the *Ordnance Survey Office*, Phoenix Park. In 1842 the official account of the Zenith sector observations is headed *Ordnance Survey*. The term, which naturally arose from the fact that the Survey was administered by the Board of Ordnance, is a very convenient one and saves the use of a longer expression. It became, in after years, the synonym for a Survey of the highest accuracy.

Effect of Roy's Death.—If we wish to measure the influence of a particular factor in any of the affairs of life we can sometimes arrive at a just conclusion by imagining the effect produced by the removal of that factor, or by watching the result of its removal. And the best proof of the large share that General Roy had in shaping these early Surveys, is that on his death they, for a short time, stopped altogether. In the *Account of the Trigonometrical Survey* for the years 1791–94, by Lieut.-Colonel Edward Williams, Captain William Mudge and Mr. Isaac Dalby, it is stated that some time elapsed after the General's decease "without any apparent intention of renewing the business." Portlock says that "after General Roy's death the subject of a Survey seemed, for a time, to be overlooked."

* See *The Oxford Dictionary*.

The Official Foundation of the Survey.—The account above mentioned goes on to say that “a casual opportunity presented itself to the Duke of Richmond of purchasing a very fine instrument, the workmanship of Mr. Ramsden, of similar construction to that which was used by General Roy (*i.e.*, a second 3-ft. theodolite), but with some improvements; as also two new steel chains of one hundred feet each, made by the same incomparable artist. Circumstances thus concurring to promote the further execution of a design of such great utility, as well as honour, to the nation, his Grace, with His Majesty’s approbation, immediately gave directions to prepare all the necessary apparatus for the purpose, which was accordingly provided in the most ample manner.” According to another account, the Duke of Richmond purchased a 3-ft. theodolite, intended for the East India Company. Portlock says that the Duke, being informed that Ramsden had made this second instrument and the two chains, “recommended to the Government that they should be purchased and the work renewed.” The 3-ft. theodolite in question is known as the 3-ft. O.S.; it is now (1924) in the Science Museum, South Kensington, and has the date 1791 engraved on the circle. The reason given for the official adoption of the Survey is not convincing. The undoubted facts are, that Roy died in July, 1790, and that, as we shall see shortly, officers were appointed to the duty of carrying on the Survey in July, 1791. With regard to the preoccupations of the Master-General, the French Revolution had been in progress some little time—the Bastille fell in July, 1789—but France and England were not at war again until February, 1793. No doubt this was a busy time at the Board of Ordnance, but not so busy as to prevent the discussion of the question of the continuance of the Survey. It must, of course, be remembered that up to Roy’s death the operations had been carried out under the general direction of the Royal Society, with assistance from the Board, and that the instruments used had been paid for personally by the King. But the instruments were still available and it is difficult to believe the official story, published after the Duke had ceased to be Master-General, that it was the knowledge of the existence of a second theodolite which caused him to adopt the Survey officially. Such a reason appears to be quite inadequate. Official statements, however old, do not always carry conviction. The course of events was probably something like this: The Duke of Richmond was genuinely interested in Roy’s work and we know that he had always materially assisted him. On Roy’s death the Duke cast about for some means of continuing the Survey, and no doubt consulted the Royal Society, of which he was a Fellow. The military authorities, in view of the probability of war with France, realized the value of a trustworthy map of Southern England, and the Duke, who was himself a high military authority, was of the same opinion. The

Royal Society, having seen the completion of the trigonometrical connection with France, was not unwilling to be relieved of further responsibility for the Survey.

It is known that the Duke applied to Dr. Hutton, of the Royal Military Academy, Woolwich, for his opinion as to the best officers of the Artillery and Engineers to take charge of the Survey, and that Dr. Hutton recommended Major E. Williams and Lieut. W. Mudge, both of the Royal Artillery. "Dr. Hutton said that in so doing he sincerely believed he had named the best mathematicians in the two Corps, and the fittest officers for this duty. Indeed, he added, it would have been very difficult to have found persons better qualified anywhere."*

During the course of a year the various negotiations with the financial authorities, with the Royal Society, and perhaps with the East India Company, and with Ramsden with regard to the second instrument, were concluded satisfactorily and in July we find the two officers above-named definitely appointed, as shown by the following *Extract from the Minutes of the Master-General and Board of Ordnance*† :—

12th July, 1791.

"G. W. Phipps, Esq., Under Secretary to the Master-General, having, by letter of the 10th inst., signified that his Grace had appointed Major Williams and Lieut. Mudge, of the Royal Regiment of Artillery, to carry on the Trigonometrical Survey with the assistance of Mr. Dalby, and desired that they might receive an Extra Allowance equal to their pay and half-pay whilst actually in the field which would be 22s. 6d. per day to Major Williams and 7s. 6d. per day to Lieut. Mudge besides the usual allowance per mile for travelling from place to place and that a party of Artillery who were to assist were to receive one shilling per day each while employed."

"Ordered that the above Allowances be paid."

It may, therefore, be taken that the date of the official constitution of the Ordnance Survey was the 10th July, 1791. The personnel of the Survey consisted of the three above-named, Major Williams, Lieut. Mudge and Mr. Isaac Dalby; they were assisted in the field by a working party of artillerymen. Poles, scaffolds, ladders and such apparatus were provided by the Board of Ordnance. Williams, Mudge and Dalby all worked in the field and Dalby was especially responsible for the computations. The principal instruments used were the new 3-ft. theodolite of Ramsden (the Royal Society theodolite was not used again until January, 1799, being meanwhile laid up in the apartments of that Society), two new 100-ft. chains, and a transit instrument combined with a telescopic level, for use in measuring bases, all by Ramsden.

* *Memoirs of the Mudge Family*. S. R. Flint. Truro. Netherton & Worth. 1883.

† Communicated by Mr. Cary, the War Office Librarian.

It may be interesting to note that the fame of Ramsden's instruments had by this time spread over the world. In the same year (1791) the German geodesist Johann Georg Tralles and the Swiss geodesist Ferdinand Rudolf Hassler, of Aarau, measured a base-line $7\frac{3}{4}$ miles long together, for the Survey of Switzerland, using a steel chain made by Ramsden. Later on, the government of the Canton of Berne voted six hundred dollars for the purchase of a suitable theodolite and "Mr. Ramsden in London, then the most celebrated instrument maker living, for a sum somewhat exceeding this amount, promised to supply in 1794 a complete azimuth circle, at least three feet in diameter. Due to various delays the great instrument did not reach Berne until 1797 . . . Ramsden's three-foot theodolite was a wonderful instrument . . . What a privilege for young Hassler to become practically acquainted with the use of an instrument of the high type that very few surveyors then living had ever seen!"* The three years' delay is characteristic; we have seen that Roy suffered from a similar delay in the provision of the first theodolite. The young Hassler was afterwards the founder of that admirable department, the United States Coast and Geodetic Survey, which was suggested by him in 1807, approved by Congress in the same year, but not actually organized until 1816, Hassler being the first Superintendent.

The First Director.—The following are the services of Edward Williams as recorded in the *List of Officers of the Royal Artillery*:—Siege of Belle Ile, 1761; Adjutant, North America, 1777; on the Staff of Lord Hood; on the Staff of General Pattison, Governor of New York, 1775–1780.† (Belle Ile is an island some eight miles south of the peninsula of Quiberon, in Brittany, about midway between L'Orient and St. Nazaire; it was captured in 1761, and was held by British troops until 1763, when it was exchanged with the French for Nova Scotia). The next thing we know about Williams is that, as already mentioned, he was recommended by Dr. Hutton as an officer whose mathematical attainments fitted him to take charge of the Survey; he was a Major when he was appointed, in July, 1791, and if we may assume that he was at least 18 at the siege of Belle Ile, he would have not been less than 48 years old when he first took charge of the Survey. In collaboration with Mudge and Dalby he wrote the account of the Survey for the years 1791–94; he was then a Lieut.-Colonel. With them also he wrote the account for 1795–96, being then described as Colonel. He died in 1798, and it is curious to note that Mudge, in his account of the operations for 1797–99, makes no mention of Colonel Williams or of his death.

* *The Scientific Monthly*, Aug., 1921. Article by Professor Florian Cajori on *Swiss Geodesy and the U.S. Coast Survey*.

† Kindly communicated by the Secretary, R.A. Institution.

We may, perhaps, suppose that he was in failing health for some years and it is not unlikely that Mudge was in effective charge of the work. At the best, Colonel Edward Williams, R.A., the first official Director of the Ordnance Survey, is to us but a shadowy and unsubstantial figure ; we know nothing of his form or features, and, beyond the fact that he was a good mathematician, nothing of his abilities or character.

The Headquarters of the Survey.—From 1791, for fifty years, the offices of the Survey were in the Tower of London, which was the headquarters of the Board of Ordnance. On a plan made about 1685, by order of Lord Dartmouth, Master-General of the Ordnance, the office of the Ordnance is shown on the south side of the enclosure, touching the Lanthorn Tower and the Constable's Lodging. This was a small building and probably only sufficed for the general administration of the department. The Survey offices were almost certainly in an armoury to the north of the White Tower, abutting on the Bowyer Tower ; the site of this armoury is now occupied by barracks. About 1791 the Master-General appears also to have had an office in Pall Mall. However, it was to the Tower that Williams, Mudge and Dalby returned after their season's work in the field, and many of the early letters are written from the Drawing Office in the Tower.

The Royal Military Surveyors.—The chief draughtsman in the Tower was Mr. Gardner, who is thus mentioned in the account of the operation for 1791-94 : " We have to acknowledge the services of Mr. Gardner, Chief Draughtsman at the Tower, by whose assistance, from his intimate knowledge of the county of Sussex, we have been able to determine, with certainty, the names of many places, which we might otherwise have considered as doubtful." In the accounts for 1795 " Mr. Gardner, Chief Draughtsman in the Tower," is stated to have accompanied Mr. Dalby into Kent, to assist in observing with a small theodolite. Portlock says that a Corps of Surveyors and Draughtsmen had been established by the Duke of Richmond ; and if so, this Corps must have been formed before 1795. The " Corps " was to be employed for filling in the topographical details required for the one-inch maps ; Mr. Gardner may have been an official under the Board before the formation of this Corps. In the preface to the account of the Survey for the years 1800-09 it is stated that the secondary triangulation in the south of England was " made subservient to a regular Survey, performed by the Royal Military Surveyors," who are presumably the Corps of Surveyors and Draughtsmen mentioned by Portlock.

The Operations of 1791-98.—We have seen that Williams, Mudge and Dalby formed the Staff of the Survey on its foundation in July, 1791 ; and that they had available Ramsden's new 3-ft. theodolite, originally intended for India, two new steel chains specially made

by Ramsden, and minor instruments. Their headquarters was the Tower of London, and they were immediately under the Board of Ordnance, which provided for them a working party of artillerymen and all necessary material.

The first thing that they set out to do was to re-measure, with Ramsden's new chains, the base on Hounslow Heath that had been measured in 1784 by Roy. It is not necessary to go into the details of this measurement, beyond saying that the chains were supported in wooden coffer, which rested on trestles; the trestles were those used by Roy and were lent for the purpose by the Royal Society. The measurement began on the 15th August, in the presence of Sir Joseph Banks, Dr. Maskelyne, Astronomer Royal, and several other members of the Royal Society. It was finished on the 28th September, Dr. Maskelyne, Dr. Hutton, Professor of Mathematics in the Royal Military Academy, and Mr. Ramsden being in attendance, by desire of the Duke of Richmond. Every precaution was taken and the mean of the two measurements was found to be $2\frac{3}{4}$ inches longer than Roy's glass tube value. The mean of the two results of 1784 and 1791 was accepted as the true length of the base, namely, 27404.2 feet.

On the approach of the Spring of 1792 a reconnaissance was made of the country about to be triangulated, which included some of the points already observed as by Roy. Lamps, to observe to, "were constructed by Mr. Howard of Old-street, which were afterwards found equal to everything which could be expected of them." Later on in the year observations were made with the new 3-ft. instrument, at the Base, and on hills as far to the west as Butser and Chanctonbury Ring. Certain points on the coast were intersected "for the construction of some maps that were making for the Board of Ordnance"—no doubt, maps for defensive purposes. Early in 1793 a site for a base of verification was selected on Salisbury Plain, between Beacon Hill, near Amesbury, and the Castle of Old Sarum. This base was measured in 1794 with Ramsden's new steel chains; the measurement occupied seven weeks. The length, when all corrections had been applied, was found to be 36574.4 feet. The length as determined through the triangulation, from the Hounslow Heath base, was 36574.3 feet. But, when the same base was re-measured in 1849 with Colby's bars, its length was found to be 36577.85 feet. The difference between the two measurements is chiefly due to a difference in the standard foot; when reduced to the Ordnance standard the old value differed from the new by about 1 foot. In 1849 it was stated that the guns marking the terminals of 1794 did not appear to have moved sensibly.

Meanwhile, during these seven years, the triangulation proceeded steadily along the south of England, until, by the end of 1795, a double chain extended from London to Land's End, and sufficient numbers of points were fixed in Kent and Sussex for the detail

one-inch Survey. "The chief draughtsmen and surveyors belonging to the Drawing-room in the Tower, attended our operations in this county (Kent), and also those afterwards carried on in Essex. It was indeed for their immediate service that we renewed the Survey in this quarter, as the Master-General had given directions to prepare ample materials for completing the map which meets the public eye with this article." (July, 1800.) The organization was evidently imperfectly developed, the chief draughtsmen and surveyors (Royal Military Surveyors?) being apparently under the direct orders of the Board. In 1795 Ramsden's 18-inch theodolite was first used for the Survey of Kent.

The Geodesy of the Operations.—It was considered that "directions of meridians," that is azimuths, should be observed "in order to afford the necessary data for computing the latitudes and longitudes . . . it is expedient that new directions of meridians should be observed when the operations are extended in eastern or western directions over spaces of sixty miles from fixed meridians."

It must be remembered that at the end of the 18th century all the processes of the higher surveying were in a tentative stage, though the fundamental notions were very well known. The actual procedure for calculating the latitudes and longitudes of the trigonometrical points was, briefly, the following: The observed spheroidal angles were reduced to those made by the chords, the spherical excess calculated, and the triangular error equally distributed; the sides of the triangles, *i.e.*, the lengths of the chords, were computed; the curvature of the meridian for the south of England was derived from the observations of 1787-88, between Greenwich and Paris; from this curvature the latitude of one of the connected stations was calculated as deduced from Greenwich, then the latitude of a second connected station; then, knowing the latitudes of these two stations (say, Beachy Head and Dunnose), "and the angle which those stations make with each other and the pole," the difference of longitude was computed by spherical trigonometry. It was for the last stage of the calculation that the *observed* azimuths were required.

In those days it was easy to get a very fair value for the local curvature of the meridian, but there were obvious difficulties in obtaining any accurate determinations of difference of longitude. It will probably be agreed that the system adopted was a good one. There was no accepted, or even approximately accurate, "figure of the earth," and in practice the officers of the Ordnance Survey, at the end of the eighteenth century, measured the curvature in two directions as they went along.

The One-Inch Map.—From 1791 onwards for the next thirty-three years the object of the Survey is definitely the production of a one-inch map of the United Kingdom. The one-inch scale was quite familiar to soldiers in those days, and, though the public was gener-

ally accustomed to smaller scales, there were, as a fact, certain privately produced maps, on the one-inch or larger scales, available for general use. "In the last half of the eighteenth century a great number of county maps were published. Their issue may without much doubt be traced to the offer by the Society (the Royal Society of Arts) of a prize of £100 for the map of any county on the scale of one inch to the mile. In justification of this statement it may be said that, of the county maps mentioned by Gough in his great work on British topography, published in 1780, as being issued or in hand at that date, nearly all appear to be of a later date than 1762; and the same may be said of a list of inch maps . . . by Sir George Fordham, the great authority on this subject."* The earliest maps produced under this stimulus appear to be one of Dorsetshire, by Isaac Taylor, about which Gough states that it "is very faulty in the place names"; and one of Devonshire (1765) by Benjamin Donn, engraved by Jefferys. Donn received the £100 prize.

Other county maps, produced in response to the invitation of the Society of Arts, were those of Derbyshire (1767), Northumberland, Leicestershire, Somersetshire, Suffolk, Lancashire, Hampshire (1793), Sussex (1796), Oxfordshire, North Wales, Cardiganshire, Shropshire (1809). The maps of Hampshire and Sussex were produced by William Faden, who received £50 for the former and a gold medal for the latter. Faden also, in 1799, published a map of Kent, based on the triangulation, by permission of the Board of Ordnance. The Ordnance Survey owes a good deal to William Faden, for it was he who undertook the publication of the *Account of the Trigonometrical Survey of England and Wales*. The first volume is dated 1799, the second 1801, and the third 1811; the three volumes carry the history of the operations from 1784 to 1809. In the preface to the first volume it is stated that "Since the commencement of the operation . . . it has been always lamented that narratives of its progress should be confined to the volumes published by the Royal Society," and the Royal Society "readily acquiesced in Mr. Faden's proposal to" republish what was necessary from their transactions. Faden is described as Geographer to His Majesty and to the Prince of Wales. He had a shop in Charing Cross. After Faden's death James Wyld, senior, became Geographer to the King; he was succeeded by his son, James Wyld, junior, and on the death of the latter the title was conferred on Edward Stanford, who started his business on 1st October, 1852, at 6, Charing Cross. Faden seems to have died about 1832.

* *Journal of the Royal Society of Arts*, Jan., 26th 1912. The writer is indebted to Mr. E. Heawood, of the Royal Geographical Society, for this reference.

John Cary received a gold medal in 1804 for his map of Cardigan-shire. "The name of John Cary is associated for nearly three-quarters of a century with geographical publications . . . In the manufacture of globes he worked with his better-known brother, William Cary (1759-1825), who had a considerable reputation as an astronomical instrument maker, and in the cartographical work he was associated with others of his name."* In the opinion of Sir George Fordham "Cary probably found his inspiration in respect of the art of cartographical representation of surface details" in the sheets of the map of France by Cassini de Thury, of which the earliest is dated 1756. Most of Cary's county maps were on scales smaller than one-inch, but not all, for we have a map of Oxfordshire in 16 sheets, on the scale of two inches to one mile. Cary is best known as the publisher of the road-book called the *New Itinerary; or an Accurate Delineation of the Great Roads of England and Wales*, which ran through 11 editions between 1778 and 1828.

Other county maps to be mentioned are those of Derbyshire by P. P. Burdett; Leicestershire, Cheshire and Lancashire by J. Whyman; Northumberland (1773) by Lieut. Armstrong, "said to have been a capital map," and others due to the same movement; also Rocque's map of Shropshire, produced independently. Then there is the admirable 2-inch map of Wiltshire by Andrews and Dury, published in 1773. We are here concerned particularly with maps on scales of about one-inch to one mile. Of maps on smaller scales (atlas scales) there is a long history beginning with Christopher Saxton's Survey of the English counties, published in 1579, and following on with John Speed's Atlas in 1611.

One thing is common to all these county maps; they were printed from engraved copper plates. In the earlier maps the hill features are shown in profile, as they are in the maps of ancient Egypt; in the later maps they are shown by hachuring of various degrees of picturesqueness. The public was thus accustomed to engraved county maps, which had been gradually improved since the sixteenth century. The Ordnance Survey, at the end of the eighteenth century, had these various county maps, Cassini's series, and other foreign maps, to serve as models. The well-known atlas of Bacler D'Albe, Napoleon's Directeur du Dépôt de la Guerre, published at Milan in 1795, to illustrate the French campaign in Italy, is a good continental example of an engraved hachured map of the period; the main features stand up very clearly and it is an easy map to read. The methods of copper-plate cartography had reached a high standard.

Inaccuracy of the Old County Maps.—Picturesque and interesting as the old county maps are, they leave a good deal to be desired on

* *The Work of John Cary and his Successors.* Pamphlet by Sir George Fordham. 1924.

the score of accuracy. Errors of 10 per cent. or more may be found on Elizabethan maps ; but similar errors exist even on the eighteenth-century maps. Thus, in the preface to the first volume of the *Account of the Survey*, dated 1799, we find the following remarks : " In the prosecution of the General Survey, frequent opportunities have manifested themselves of enabling us to discover the very erroneous state of our maps . . . by laying down on the maps of counties, particularly on Taylor's map of Dorsetshire, the distances of the intersected objects, as Dorchester Church from Nine Barrow Down, where an error of nearly three miles is detected in a distance of eighteen, an immediate proof is obtained of their great inaccuracy. Taylor's map of Dorchester (? Dorsetshire) is here specified, because we think it is the most erroneous of any we have examined ; yet those of Devonshire and Kent may be considered as similar specimens of imperfect topography." It may be noted, by the way, that Taylor's map, described by Gough as " a capital Survey," failed to get the Society of Arts prize. The preface goes on to say that " It has been very justly expected by the public, that from the present undertaking they should derive the advantage of an improvement in the geography of their country, and possess some general map, published on the same principle with the *Carte de France*, a performance highly celebrated."

In 1791 the Copley Medal of the Royal Society was awarded to Major James Rennell for his geographical work in India. The President, Sir Joseph Banks, in his address on that occasion, compared Rennell's map of India with the county maps of England, which were then available : " I should rejoice could I say that Britons, fond as they are of being considered by surrounding nations as taking the lead in scientific improvements, could boast a general map of their island as well executed as Major Rennell's delineation of Bengal and Bahar : a tract of country considerably larger in extent than the whole of Great Britain and Ireland ; but it would be injustice to the Major's industry were I not here to state that the districts he has perambulated and planned exceed, probably, in extent the whole tract of surveyed country to be found in the maps of the European kingdoms put together, while the accuracy of his particular surveys stands yet unrivalled by the most laborious performance of the best county maps this nation has hitherto been able to produce."*

We may sum up the matter thus : At the end of the eighteenth century there were many county maps, of comparatively recent date, on the scale of one inch to one mile, or on even larger scales. These maps were printed from engraved copper plates, the hill-features being shown by hachures. The engraving was good, and the maps were generally artistic productions. But the English

* *Major James Rennell*. Clements Markham. Cassell & Co. 1895.

county maps had no pretensions to accuracy ; they were inferior, in this respect, to Rennell's recent maps of Bengal, and their errors cried aloud for correction.

The Field-work of the One-inch Map.—In 1795 the Corps of Draughtsmen and Surveyors belonging to the " Drawing-room in the Tower," under Mr. Gardner, attended the trigonometrical operations in Kent. Mr. Dalby and Mr. Gardner used the new 18-inch theodolite for the fixing of secondary and intersected points on which to base the detail. No information is given us as to how the detail of the " interior survey " was mapped ; but it appears to be almost certain that this interior, or detail survey, was carried out by compass and pacing, or cyclometer, and was executed on the 2-inch scale in the field. Although the plane-table had been known practically, in its modern form, for more than two hundred years, and although in certain parts of Great Britain, notably in the Down country, and in the mountains of Cumberland, Wales and Scotland, the plane-table is without rival as a surveying instrument for work on the one-inch and similar scales, it was never adopted by the Ordnance Survey.

The plane-table might have been most profitably used between 1795 and 1825, a period during which there was only the one-inch map to think of. The ignorance which prevailed as to the value of the plane-table lasted to a much later date. For instance, the Palestine Survey, which was begun in 1871, was carried out, as regards the detail, by means of the prismatic compass, and this in a country which is exceptionally suited to the plane-table. The explanation given is that " the N.C.O.s in Palestine were familiar with the compass and it is very handy in riding."* The writer remembers that, as late as 1897, the field training of the topographical sections of the Ordnance Survey, which were intended for service abroad, was confined to the prismatic compass. However, for good or ill, the detail of the old one-inch map appears to have been surveyed inside the fixed trigonometrical points, by the compass. There was not room for much accumulation of error ; and although such a procedure results in a " loose " survey, the early sheets of the old one-inch map were, as regards accuracy, greatly superior to any previously existing maps of this country.

* *The Trigonometrical Survey of Palestine.* Major C. R. Conder, D.C.L., LL.D., R.E. R.E. Professional Papers. 1894.

IV. THE DIRECTORATE OF WILLIAM MUDGE.

William Mudge.—William Mudge was officially superintendent of the Ordnance Survey for 22 years ; and even before he was formally in charge there is reason to suppose that he did, as a fact, have a principal share in the direction of the operations of the Survey from the year of its foundation in 1791; for Colonel Williams, the nominal Director, took little or no part in the work. We must picture quite a small department, almost too small to be called a department, consisting, as it did, of two officers and Mr. Dalby or Mr. Woolcot, a working party of artillerymen, a few surveyors and draughtsmen from the Ordnance, and one or two engravers. During Mudge's lifetime the object of the Survey remained the production of a one-inch map of Great Britain. Ireland was not originally included in its scope, and large-scale maps had not yet been thought of.

William Mudge was born at Plymouth on December 1st, 1762. His father was Dr. John Mudge, F.R.S., a celebrated physician, the friend of Dr. Johnson and of Sir Joshua Reynolds, both of whom held Dr. Mudge in high esteem. Dr. Johnson was William's godfather. Dr. John Mudge's father was the celebrated divine, Zachariah Mudge, Vicar of St. Andrew's, Plymouth, who was born in 1694. Dr. Mudge relates that when the news of Wolfe's victory at Quebec arrived he hastened to his father (Zachariah) with the Gazette; on hearing the news his father said, "Son, son, it will do very well, whilst the Americans have the sea on one side and the French on the other; but take away the French, and they will not want our protection." He saw clearly, at the moment, in the capture of Quebec, the expulsion of the French from Canada, and the consequent independence of America.* William Mudge was sent to the Military Academy at Woolwich in 1777, and while he was there he was visited by Dr. Johnson, who gave him a guinea and a book.† "Of his time at Woolwich Dr. Hutton said he was a sharp boy, but not particularly attentive. There were at that time . . . two Academies, the Senior and the Junior; over

* *Memoirs of the Mudge Family.* S. R. Flint.

† *Memoirs of the Mudge Family.* S.R. Flint—Truro. Netherton and Worth. 1883. From this book much of what follows is taken.

the first Dr. Hutton presided, and in the Junior a Mr. Charles Green, who was rather remarkable for his slowness in teaching." In 1779 Mudge got his commission as a 2nd Lieutenant in the Royal Artillery, "and was sent out almost immediately to South Carolina where he served in Lord Cornwallis's Army. During this time there is mention made in his father's pocket-book of his writing home from Charlestown." He was promoted 1st Lieutenant in 1781.

On his return from America he was posted to duty in the Tower, and whilst he was there he commenced the serious study of mathematics, being partly moved thereto by the example of his brother officer, Shrapnel. He was helped in his studies by Dr. Hutton, who was thus very well able to judge of his abilities. In 1791, on Dr. Hutton's recommendation, Mudge was appointed to serve under Colonel Williams, who was put in charge of the Survey by the Duke of Richmond. In 1798 Colonel Williams died; his death removed an incubus that might have been fatal to the Survey. Mudge's ability and his experience of the work marked him out as the man to succeed, and he was directed to take charge of the Survey by the following minute:—

" Sir,

I have the commands of the Master-General to acquaint you that, sensible of the zeal and ability you have shown in that part of the Trigonometrical Survey, which it has fallen to your lot to execute on the death of Lieut.-Col. Williams, it was his Lordship's intention to have intrusted to you the conduct of its continuation; and it is with additional satisfaction and confidence that Lord Cornwallis now appoints you to that situation, assured of its coinciding with the wishes of his Grace the Duke of Richmond.

His Lordship desires that you will accordingly take on yourself the charge, as it has hitherto been held by Colonel Williams.

I have the honour to be,

" R. APSLEY."

Although R. Apsley wrote officialese, his meaning is clear enough, and Mudge now became Superintendent of the Survey, and remained in that office until his death.

In the same year, 1798, he was elected a Fellow of the Royal Society; the President, Sir Joseph Banks, informing him that the Fellows "were well aware of the zeal, diligence and ability he had shown in executing the interesting duty in which he was engaged." From 1798 to 1808, Mudge lived at the Tower; in the latter year he bought No. 4, Holles Street, which was his home for the rest of his life.

In 1809 he was unexpectedly appointed Lieutenant-Governor of the Military Academy at Woolwich; but he did not give up the direction of the Survey. "He found the Academy, as he said, in

ruins ; to remedy the state of things he at once struck at the root of the evil, and set to work to bring about better discipline, and management, among the Cadets." The appointment was made by Lord Chatham, who, in a letter to Mudge, written in 1817, expresses, not only his high satisfaction at the success with which his Survey continued to be executed, but added that it was " no less gratifying to him to learn that the Royal Military Academy has so fully answered all that was expected from it, and that it has attained that degree of perfection, the accomplishment of which was, he was confident, best insured when it was placed under Colonel Mudge's auspices."

But yet another duty was to be entrusted to this indispensable officer. Since 1798 the cadets for the Artillery and Engineers of the East India Company's service had been trained at the R.M.A., Woolwich. But in 1810 the Company established its own college at Addiscombe, the cadets in question being moved from Woolwich. Colonel Mudge was asked to superintend this new College, in addition to his existing duties. Small wonder that in 1811 we find him writing, " My labours are great and I am without strength to carry my chains. I can assure you that I am a slave, and not wearing golden chains." And again, " I have more business on my hands than I have strength for, or, if I had strength, even time to perform, and this has always been the case." What with his duties at the Tower and in the field superintendence of the Survey, what with his work as Lieutenant-Governor of the Academy at Woolwich, and as Superintendent of his College at Addiscombe, he could have been very little at Holles Street. And it would appear, also, as certain that, in spite of his capacity and energy, the work of the Survey must have suffered but for one fact ; and that is, that he had, in 1802, selected, as his chief personal assistant in the direction of the Survey, an officer who was destined to impress his mark very deeply upon that institution, and whose zeal and ability equalled his own—namely, Thomas Colby.

In the summer of 1819 Mudge was promoted Major-General. Early in January, 1820, he was laid up at Addiscombe with some internal complaint. He returned to Holles Street and got better, but had a relapse, rapidly became worse, and died on the 17th April, 1820, in his 58th year. He had married the daughter of Major-General Williamson, R.A., and had five children—one daughter and four sons—two of whom became officers in the R.E., one in the R.A. and one in the Navy. He was noted as a man of great amiability of disposition and evenness of temper ; devoted to his family ; an excellent chief, kind and considerate ; upright and scrupulously attentive to the public interest.

It may, perhaps, be appropriately mentioned here that there is a letter in the Colby collection, written to Colby by Isaac Dalby (then an old man), which confirms the suggestions made above as

to the inefficiency of the first superintendent of the Survey. The letter is as follows :

Farnham.
February 5th, 1821.

“ Dear Sir,

I should have acknowledged your letter sooner, but am so much plagued with age and the rheumatism that I feel it very tiresome either to think or write : for the latter disorder the Doctor prescribes flannel and patience ; but I derive little benefit from following his advice—age, indeed, is a growing complaint ; and except one could get a dip in Medea’s kettle there is no chance of getting rid of it.

You learn from the publications that I was a fellow labourer, from 1791 to the autumn of 1799, with our late worthy and much lamented scientific friend [Mudge] ; who always was zealous, active, and indefatigable in carrying on the Survey. Independent of his exertions, however, and prominent services in the undertaking, I do not recollect a circumstance derogatory to his character as a gentleman.—But truth compels me to drop eulogy in noticing our colleague Col. W[illiams] who nominally was the principal ; I say *nominally*, because he never made an observation, or calculation, nor did he write a line of any of the printed accounts ; in fact, he proved a dead weight in the undertaking by frequently retarding its progress : and the only time he benefited the service, was when he took his departure to the next world.

I have yet to learn what disorder was the immediate cause of the General’s death. I know he had sometimes been subject to the *hyp*, or something like it ; particularly when we were measuring the base on Sedgemoor : at that time he often complained of *depression of spirits*, but found relief from exercise on horseback. It was rather singular, however, that he always got into the most unfrequented parts of the country in his equestrian excursions.

Our routine of proceedings year after year had so much sameness, that I think you may collect what is necessary from the printed Accounts, and more to the purpose than I could furnish from recollection, after a lapse of more than twenty years, at my time of life ; for I now find myself much more dexterous at forgetting than in remembering.”

It is, therefore, clear that Mudge was in effective control of the Survey—that is, so far as Williams did not put difficulties in the way—from 1791 to the date of Williams’s death in 1798. From that date, until his own death in 1820, Mudge was officially and actually in charge of the Survey. From 1809 he was also Lieut.-Governor of the R.M.A., Woolwich, and from 1810 he was, in addition, Superintendent of the H.E.I.C.’s College at Addiscombe. From the nature of the case, after his assumption of these other duties, much of the direction of the Survey fell into the very capable hands of his friend and junior colleague, Thomas Colby. There is no doubt that the arrangement worked well, as it was bound to with two such reasonable and clever men as Mudge and Colby.

Work in 1799.—One of the first things that Mudge did, after assuming charge of the Survey, was to ask the Royal Society to lend Roy's 3-ft. theodolite. He says that "in very early stages of the work I had frequent opportunities of observing, that eminent advantages would accrue to the service, were the survey prosecuted on a more extensive scale. The consideration of a grand instrument being laid up in the apartments of the Royal Society suggested the propriety of obtaining it; therefore, when my appointment to my present situation gave me the means of effecting former ideas, I lost no time in applying to the President and Council for the loan of their large theodolite." (Probably Williams had vetoed the idea.)

The Royal Society readily granted Mudge's request and the instrument was put into Ramsden's hands early in January, 1799, for the purpose of having new microscopes fixed to it. Ramsden was also asked to complete the zenith sector which had been ordered by the Duke of Richmond in 1795.

In this year, also, Mr. Gardner, the chief draughtsman, was furnished with materials for mapping the north shore of the Thames and the North of Kent. The triangulation during 1799 covered an area, generally north and west of London, of some 5,000 square miles, reaching a little to the north of Coventry, and west as far as Broadway Beacon in Gloucestershire.

Mudge remarks that "the highest advantages would accrue—a word he was very fond of—to geography, were the ideas of the Astronomer Royal carried into execution (and which I shall endeavour to do at some future period), respecting the discovery of the difference of longitude between Greenwich and some very remote point on the western side of the island (St. David's Head, for instance), by means of timekeepers, carried backwards and forwards in the mail coaches."

Position of the Scilly Isles.—The angles to points in the Scilly Isles were observed from stations near Land's End in 1797; and, when the distances were subsequently computed, they revealed a large error in the hitherto accepted longitudes of those islands. Mudge says, "How in a maritime country like our own, where chronometers are in such constant use, so great an error as 26' 37" (1m. 46½s. in time), in the longitude, should have remained undetected except by one person, is surprising. J. Huddart, Esq., visited the Scilly Isles, having with him a watch made by Arnold, and obtained his time at that spot, in the island of St. Mary, where the body of Sir Cloudsley Shovel is said to have been thrown ashore. . . . he then found a large difference between the real longitude and that published in the *Requisite Tables*."

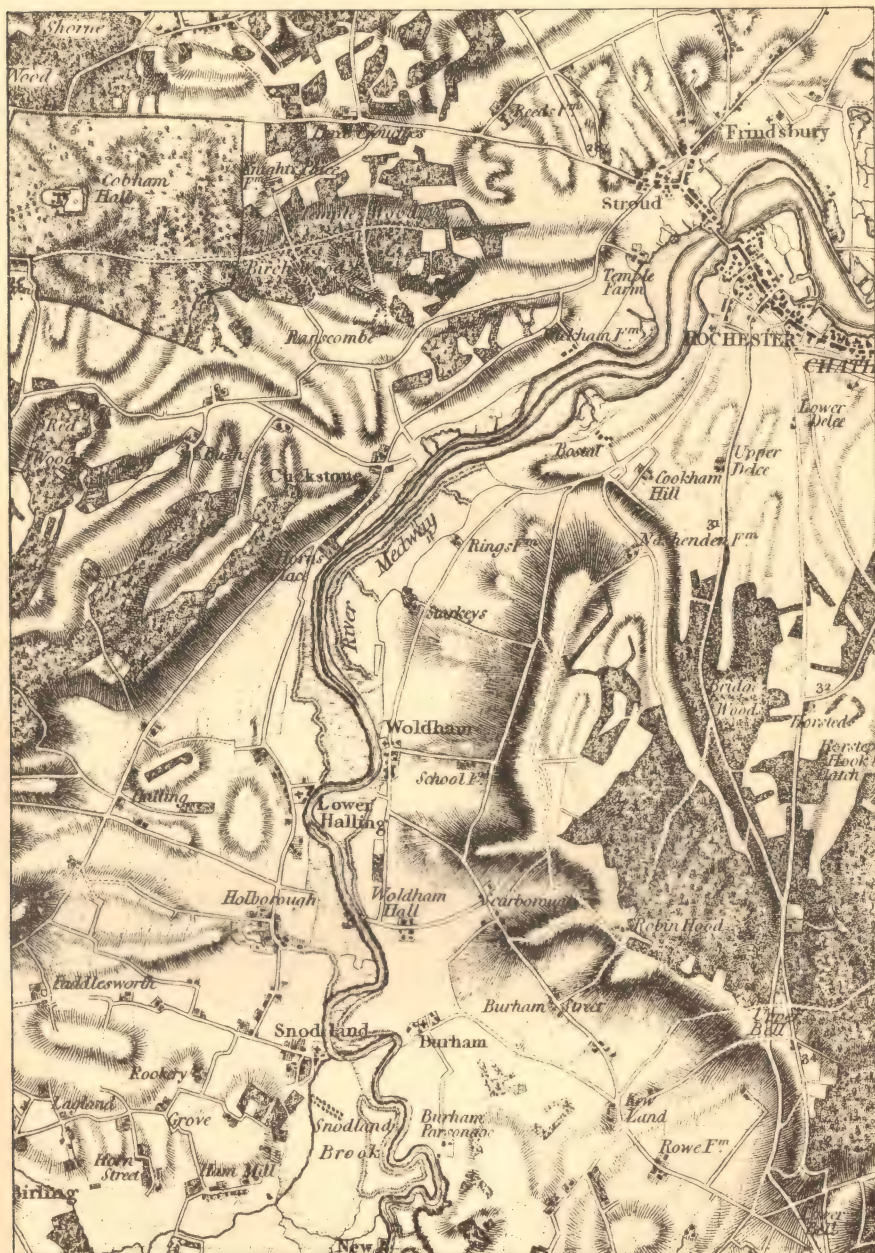
We shall see that, forty years afterwards, important islands off the coast of Scotland were, before the publication of the Ordnance maps, misplaced on the charts and maps by almost equally large distances.

Terrestrial Refraction.—Mudge devoted much attention to the subject of terrestrial refraction, and, in the account for the years 1797–99, the refraction, in quite a modern way, is given as a fraction of the contained arc. He mentions the great uncertainty and variability of terrestrial refraction and quotes an instance of this in the vertical observations from Pilsden Hill to Glastonbury Tor. It was not found possible to devote very much time to the subject, but Mudge and Woolcot made careful hourly observations at three stations, noting the temperature, air pressure and state of the wind. The mean value of the coefficient of refraction at these stations worked out to about '09. Mudge says, "the little done on this subject points out the necessity of doing more."

The First Ordnance Map.—By the "first ordnance map" is meant the first map issued, by the Ordnance Survey, for the use of the public. It is stated, in the Account for 1795, that a necessity existed for "completing the Map of Kent for the Board of Ordnance, by order of the Master-General." In the Particulars relating to the operations of the year 1798, Captain William Mudge says that the Survey of Kent was renewed in this year, "as the Master-General had given directions to prepare ample materials for completing the map which meets the public eye with this article." "This article" was read before the Royal Society on 3rd July, 1800. But in the Preface to the Account of the Operations from 1784 to 1796, *i.e.*, Volume I, Mudge and Dalby state that Mr. Faden was permitted "to engrave, under certain restrictions, this Map of Kent for public use. . . . These instructions have been carried into effect, with the assistance of Mr. Gardner, by whom the map has been finished in a masterly manner, and will be published by Mr. Faden in the course of the present year" (1799).

This map of Kent, the first of the ordnance maps, which is thus variously described, was actually published by W. Faden of Charing Cross on 1st January, 1801. It is on the scale of 1 inch to 1 mile and is engraved on copper, in four sheets, each about 33½ inches by 22½ inches. It includes the East part of London, the South part of Essex and the whole of Kent. It is entitled *General Survey of England and Wales, an Entirely New and Accurate Survey of the County of Kent with Part of the County of Essex. Done by the Surveying Draughtsmen of His Majesty's Honourable Board of Ordnance, on the basis of the Trigonometrical Survey.* There is a dedication to Lord Cornwallis and the Board, *by their most obedient and faithful servant, W. Mudge.* The dedication is dated, *Drawing Room, Tower, January 1st, 1801.* The first of the ordnance maps appeared, in fact, on the first day of the new century. Thos. Foot was the engraver, and it is probable that the engraving was done under Faden's direction. Although the hachuring is, in parts, a little harsh, the work appears to be equal to the best continental

THE FIRST ORDNANCE MAP.



From the Map of Kent on the Scale of one-inch to one-mile. Published by W. Faden, 1st January, 1801.
Dedicated to the Master-General and Honourable Board of Ordnance, by W. Mudge.

Ordnance Survey 1924

productions of the time, and a good deal superior to the early Cassini maps and the general run of English county maps. It is curious that the next county to be published, Essex, has the title, *Part the First of the General Survey of England and Wales, done by the Surveyors of His Majesty's Ordnance under the direction of Lieut.-Colonel Mudge, of the Royal Artillery, F.R.S.* This is in four sheets, each 23 inches by $34\frac{3}{4}$ inches. It has the imprint, "*Published April 18th, 1805, by Lieut.-Colonel Mudge, Tower. Engraved at the Tower.*" So that by this time the surveyors and engravers were under Mudge's orders, and the maps were published by him. The hachuring of the Essex sheets shows an advance on anything done before, in fact, it had practically reached its final form.

The old hill-hachuring of Cassini's Carte de France left much to be desired: "Mais où la carte de Cassini se montre le plus inégale, toujours médiocre, souvent inférieure aux cartes locales contemporaines, c'est dans la représentation du relief. Les hachures, supposées suivant les pentes, ne sont d'accord ni avec leur raideur, ni avec l'importance des différences de niveau, ni avec les formes du sol. Elles n'expriment guère le terrain, à la manière d'une esquisse très grossière, que lorsqu'il s'agit de vallées d'érosion ouvertes dans l'épaisseur d'un plateau."*

This is exactly the idea that the present writer received from studying the sheets of the Cassini map; before reading Colonel Berthaut's account, he had written that this French map gives the impression of deep river channels in an eroded plateau. The English county maps, published before 1800, usually give the same impression; take, for instance, the interesting map of Wiltshire, on the 2-inch scale, published by Andrews and Dury in 1773, or the map of Essex, by Chapman and André, published in 1777. The Ordnance Map of Essex of 1805 does really, on the other hand, represent the relief almost as well as it is possible to do by hachures; where this system fails is in representing long slopes and gentle undulations. It is not, on the whole, a satisfactory method and is now almost obsolete.

The scale of the Carte de France of Cassini (de Thury) was 1 : 86400. It was begun in the field in 1750, and was finished in the field in 1789, but its publication was not completed until 1815. Napoleon was unwilling that his enemies should possess a complete and detailed map of France—"l'Empereur estimait qu'une carte détaillée est une arme de guerre." Its successor, the "Carte de France au 80,000^e", was proposed by Colonel Bonne in 1808; the project was revived in 1814 by General Bacler d'Albe, Directeur du Dépôt de la Guerre, and was supported by Laplace in 1817, who presided over the committee which was the first of many to discuss the

* *La Carte de France, 1750-1898.* Col. Berthaut, Service Géographique de l'Armée.

scheme. The work was begun in 1818; in 1854 about two-thirds of the sheets had been published. The series was not finished until 1875.

These facts are mentioned to give an idea of the slow rate of progress of these celebrated French maps. It was just the same in this country. We shall see that the old one-inch dragged on for more than half a century.

Mudge's Arc of Meridian.—The geodetic operation with which Mudge's name is most closely associated, an operation which, in fact, he largely carried out himself, is the measurement of an arc of meridian from Dunnose, near the southern extremity of the Isle of Wight, to Clifton, a village in Yorkshire, a distance of 196 miles. The objects of this measurement were, first, to determine the varying curvature of the meridian passing through the greater part of England, for use in computing the latitudes and longitudes of the triangulation; and the second purpose was to provide additional information with regard to the figure of the Earth. With regard to the first object it may be pointed out that there was no strict necessity for determining latitudes and longitudes, so far as concerns the making of a one-inch map of England and Wales, or even of Great Britain. For the whole map could have been plotted—as, indeed, it was later on—by a well-known system which is almost the equivalent of assuming a plane earth; and for such a small range in longitude the errors involved in the projection give rise to no practical inconvenience. On the other hand, latitudes and longitudes derived from the Ordnance Survey were required for nautical charts, especially of the coast-line and islands; and it is known that at the beginning of the nineteenth century there was very considerable uncertainty about the positions of the surrounding small islands, especially, of course, with regard to their longitudes. We may, therefore, consider the measurement of this arc as a very proper operation, and a necessary one, if full use was to be made of the Survey.

Mudge considered carefully the best meridian to choose for the purpose. That which passes through the greatest extent of the land-surface of Great Britain is the meridian three degrees west of Greenwich, but this has the disadvantage of traversing much mountainous country, including the marches of Wales, Cumberland, and the eastern highlands of Scotland, and the observed latitudes along such a line would certainly be much affected by local attraction; so Mudge, in order to avoid a line so likely to involve serious deflections of the vertical, chose the meridian of Dunnose.

The account of the measurement was read by Mudge before the Royal Society, on June 23rd, 1803. It was published in *Philosophical Transactions*, and republished by William Faden in 1804, as the second part of Vol. II of the *Account of the Trigonometrical Survey*.

Many pages of this account are devoted to a description of Ramsden's zenith sector, the remarkable instrument with which the latitudes were observed. This instrument had been ordered by the Duke of Richmond before 1795, and it is stated that Ramsden "from the beginning of the year 1800 till the middle of the following summer, had proceeded with little interruption, except from illness, towards its completion. The whole was brought so near to a conclusion before he died, that Mr. Berge found no difficulty in rendering it sufficiently perfect." It was delivered to Mudge in April, 1802, and, after some days' testing and experimental observation at Greenwich, it was set up on the down at Dunnose on the 9th May. Mudge says that one very material service accrued to himself during the time that the sector was being tested at Greenwich, and this was "the advice and instruction I received from the Astronomer Royal, for the successful management of the sector, by which I scrupulously governed myself throughout the whole of the subsequent campaign."

The zenith sector, Ramsden's last work, was in every respect a noteworthy instrument and a short description of it may not be out of place. It had a telescope eight feet long with a four-inch object glass. Great pains were taken to prevent any flexure of the transit axis. The position of the zenith was given by a plumb-bob, and zenith distances could be read by micrometers for $7\frac{1}{2}$ degrees each side of the zenith. In the observations every imaginable precaution was taken by Mudge; thus, thermometers were read at various levels in the observatory tent in order to correct for any unequal expansion of arc and telescope. It is safe to say that no such accurate observations had ever before been taken in the field. The observations were admirably accordant; the measurement of the celestial arc of meridian between the zeniths of Dunnose and Clifton, by 17 different zenith stars, gave a maximum discordance of $4.19''$ and a probable error of $0.18''$, an excellent result—achieved more than a hundred and twenty years ago. Mudge observed with this instrument at Dunnose in May and June, 1802, at Clifton in July and August, and at Arbury Hill, in Northamptonshire, in September and October of the same year.

It is curious that, though the title is an Account of the measurement of an *arc* of meridian, in the text Mudge throughout uses the word *arch*, for that portion of the instrument by which the angles were measured; he writes of celestial *arcs*, but instrumental *arches*. In the account for 1800–09 he writes of terrestrial *arches*.

The angles of the great terrestrial triangles, connecting Clifton with Dunnose and the previously executed work in the south of England, were observed in 1800 and 1801 with the 3-ft. theodolite. A base was measured on Misterton Carr, not far from Clifton, in 1801, with Ramsden's two 100-ft. chains. This was the fourth base to be measured during the survey operations, the others being those

measured at Hounslow Heath, Romney Marsh, and Sedgemoor (in 1798), the latter being a base of verification for the work in the west of England. The mean length of the Misterton Carr base was found to be 26,347·7 feet of Ramsden's standard. Allowance for standard being made, this base comes out very well when tested by the final O.S. results. For a discussion of the length of a degree of the meridian Mudge was able to use the well-determined latitudes at Greenwich and Blenheim, as well as those observed by himself at Dunnose, Arbury and Clifton.

The length of a degree of the meridian, in the mean latitude $52^{\circ} 2' 20''$, was found to be 364,920 feet, a quantity which does not differ much from modern values. But Mudge was greatly concerned to find that the length of a degree in the southern portion, from Dunnose and Arbury, was greater than that in the northern portion, from Arbury to Clifton; whereas, if the earth had the shape of an oblate spheroid, the reverse should have been the case. This was a disappointment to him, as he had hoped that the stations chosen were reasonably free from local attraction. But he never doubted that the anomaly was caused by local attraction, and he was right.

Mudge, in common with the geodesists of his age, treated mountains as supported by the solid crust of the earth; a section of the crust through the mountain being imagined to have just so much extra matter piled on top of it. Now, the modern view, based on much experimental evidence, and chiefly due to the labours of Archdeacon Pratt, in India, some seventy years ago, and of Dr. Hayford, formerly of the United States Coast and Geodetic Survey, in recent years, is briefly this: Mountains are not "supported" by the solid crust; the existence of a mountain may be taken as a proof that there is, in the crust below it, material lighter than the average. In the same way, it appears probable that under the oceans the material of the crust is heavier than the average. Hayford has shown that this compensation, or balancing of high land by deficiency of density underneath it, and *vice versa*, probably takes place within a depth of about 100 kilometres, or 70 miles. So that computations of the deflections caused by the visible topography give results, in the case of hills, which are almost always too great, and are apt to be very misleading. When the effect of compensation is taken into account it is necessary to extend the computations to great distances. Moreover, though the compensation is probably very perfect when large continental areas are considered, it is not so for small areas or for small hill features, and the compensation may be considered to be spread through some distance horizontally. Also, local attractions are largely modified by local, and not general, abnormalities of density which may be only a relatively small depth below the surface.

The general condition of balance is known as *isostasy*. Much

has been written on the subject by Dr. Hayford and Mr. W. Bowie, of the United States Coast and Geodetic Survey, and by Sir Sydney Burrard, formerly of the Survey of India.* But the science of geodesy arrives slowly at its results and finality in the discussion of this matter of isostatic compensation has not yet been reached, though much progress has been made.

We need not, therefore, be surprised that Mudge's measurement of a single arc of meridian, less than three degrees long, did not give minutely reliable results, or serve to determine the figure of the earth. But the combination of many arcs, both along meridians and along parallels, and geodetic observations spread over Europe, the United States, and India, have given us very accurate information with regard to the mean figure, that is to say, the ellipsoid of revolution which will best fit the geoid, or water surface at mean sea-level. We can now say that, though we are still uncertain as to the variations of crustal density and the exact mechanism of compensation, we know the length of each of the earth's semi-axes to within about 100 metres, that is, to within one part in sixty thousand. But in Mudge's day there was no such exact knowledge of the figure of the earth, and the mean curvature which he obtained from his arc was required for, and used in, the construction of the one-inch map.

Although Mudge had not the solution, he had perfectly clear ideas as to the nature of the problem. In the Account printed in 1801 he says, with reference to "the uncertain state in which we remain, with respect to the figure of the earth": "If the earth were homogeneous, it would necessarily be an ellipsoid; and, were its diameter known, the longitudes and latitudes of places on its surface might be accurately computed, provided their geodetical situations were correctly ascertained, and the latitude of one station in the series of triangles truly determined.

"As there is, however, great reason to suppose that the earth is not any regular geometrical figure, from the impossibility of reconciling the results of the various measurements . . . some uncertainty must remain with respect to our deductions; but there seem to be reasons for supposing the errors . . . are confined within moderate limits."

Simon Woolcot.—Writing in 1800, Mudge said that "whilst I lament the loss of a man [Dalby] so perfectly calculated to assist me in this arduous undertaking, I derive every consolation from a knowledge, founded on experience, of the talents and abilities of Mr. Simon Woolcot." Woolcot joined the Survey as mathematician and observer, in succession to Dalby, in the latter part of 1799, and his service was continuous until his death in 1819.

* See also *The Earth. Its Origin, History and Physical Constitution*. by Dr. H. Jeffreys, M.A., D.Sc. University Press, Cambridge, 1924.

A few of Woolcot's letters have been preserved and these throw some light on the experience of the field-workers in the early part of the nineteenth century.

On the 4th May, 1804, he writes to Mudge from South Molton :—

" A considerable time has elapsed since the Draughtsmen of the Tower were favoured with Warrants, from a recommendation of the Master-General, as a measure highly expedient to facilitate the execution of Military Surveys, etc. I must say, I feel a considerable degree of uneasiness, as I have not received the favour of a similar indulgence, since the authority of a warrant is now become so necessary to guard me, particularly on the coast, from those insults and interruptions, in the execution of my business, which I have so frequently and so lately experienced. . . . "

On the 22nd December, 1812, he writes to Colby from Kimbolton :

" The weather . . . set in so unfavourable that notwithstanding my waiting day after day for a change I was at last compelled to return without having completed what I intended when I set out. I have returned with a slight cold and a broken Gig—however, it does not require much fortitude to reconcile oneself to accidents like these. I was sorry to find Mr. Gardner on my return so long waiting. . . . He wishes to have your permission to proceed immediately with the Survey of Norfolk. No coach passing through Kimbolton for London this day, Mr. Gardner is under the necessity of delaying the sending the Diagram of his triangles until to-morrow.

" With respect to Messrs. Hyett and Stevens I think the most convenient edge will be from Towcester on the main road in a straight line through Watling Street the old Roman way. . . . "

In the next letter there is a sentence which shows that some of the work was carried out in the field on the one-inch scale. Woolcot, writing from Kimbolton on 27th November, 1812, says :—

" Since I received your last letter I have recomputed the Cambridge-shire triangles and will lay them down on the inch scale for Mr. Yeakell as soon as possible."

In another letter, of about the same time, but undated, he gives the " latitudes " and " longitudes," *i.e.*, the co-ordinates, of certain points in Scotland, namely, Kellie Law, Red Head, Bell Rock, Dundee Law and East Lomond, with reference to Delamere ; showing that it was then intended to plot the one-inch map of Great Britain from one origin. Later on this excellent idea was given up. He ends the letter :

" I wish you fine weather for your zenith sector observations that you may not be detained long in the inhospitable Isle of Shetland."

In a letter dated May 5th, 1815, he writes :—

" I sent Mr. Dawson by the coach of yesterday a diagram of the points and distances on the two-inch scale in the neighbourhood of

Dolgelly and Cader Idris. . . . I am happy to learn from you that the United States of America have manifested such a laudable spirit of exertion by procuring instruments from this Country of such transcendent excellence for the prosecution of their Survey. . . ."

On 10th January, 1816 :—

"I am glad you have gotten a Board Order for the payment of the 1/5d. per day, etc."

On July 4th, 1816, from Carnarvonshire :—

" . . . Colonel Mudge desired me on my way to Wales to call on Mr. Dawson and to learn from him for what part points would be first wanted. Mr. Dawson informed me that as Caernarvonshire would be principally the business of the present year he could wish to have points for that district as soon as possible. . . . The range of mountains is more extensive in this neighbourhood and of superior bulk and eminence and has also in general a nearer approximation to the coast, which, perhaps, may account for a greater attraction of the humid vapours exhaled from the sea. . . .

"I expect Mr. Dawson will be very soon at Caernarvon as I understand from Mr. Forbes and his nephew Mr. Budgen. . . ."

In this letter he gives his value of the height of Snowdon as 3557 feet.

On July 15th, 1818, to Captain Colby, LL.D., etc., then in Scotland :—

"Good and evil are intimately blended and inseparable in this life, both in action and in sufferance. Your future almost inaccessible positions will supply you with an antidote of some small efficacy, . . . it will perfectly free you from all disagreeable intrusions. All those swarms of idle holiday visitors will visit you no more, they will remain at home, like flies from tempests all couched under shade. . . . I have not heard from Colonel Mudge since I left Town. I have informed him in what manner I intended to proceed with the internal survey. . . ."

At Macclesfield on December 22nd, 1818, to Capt. Colby :—

"So long a time hath elapsed since I received a letter from you that I feel very uneasy on the occasion. I wrote to you at the Tower about five weeks since on the supposition you were then returned from your expedition to France with the Zenith Sector. I wish to observe that the approaching winter would not allow me to finish the high Peak of Derby. . . . I wrote to Colonel Mudge previous to his going to France that I was in want of Paper. . . ."

The following letter was written to Capt. Colby by William Woolcot, brother of Simon, shortly after the death of the latter :—

"I have this moment received your letter of the 28th and, conformably to your Order, I have enclosed my dear Brother's last Field-pay ; which you will be pleased to hand over to the Board. . . . I mean to pay you a visit at the Tower, and whatever papers I may find in my Brother's Gig-box, relative to the Survey, shall be faithfully delivered

to you. . . . There are also several Books of computed triangles of various Counties, some maps, a Telescope, and one of Beck's patent Protractors, which shall all be returned to you. Besides, I have a good part of the Correspondence between Colonel Mudge and my most affectionate Brother. . . . I, too, should like an inscription over the remains of my lamented Brother, and the following is submitted to your consideration, alteration and amendment :—

" Sacred to the memory of S. Woolcot, Esqr., Trigonometrical Surveyor, who was born at Southmolton, Devonshire, but departed this life, at Macclesfield, while on the Survey, in the certain hope of a glorious Immortality, on Monday the 19th day of April 1819, in the 59th year of his age,—As a man he was amiable,—as a scholar, most excellent ; few were his equals in the arduous field of Investigation, and none his superiors ; but death inexorable, who pays no distinction to persons, title, nor honor, has in a moment laid this sun of genius in the dust !—The last sad tribute of affection was paid to his remains by his highly-respected Friend Captain Colby, LL.D.

" Go ! imitate his Virtues, and become also the heir of Immortality ! Virtue alone will flourish in Heaven when Time & death shall be no more.

" As a memorial of that love, which nothing but death could extinguish, this Tablet was erected by his most affectionate Brother."





[Reproduced from Autotyp.]

MAJOR-GENERAL WILLIAM MUDGE, R.A., LL.D., F.R.S.

1762 — 1820.

Director of the Ordnance Survey from 1798.

Lieut.-Governor of the R.M.A., Woolwich, from 1809.

Superintendent of the H.E.I.C's College at Addiscombe from 1810.

From a picture painted by James Northcote, R.A., in 1804.

V. THE DIRECTORATE OF WILLIAM MUDGE
(Continued).

Colby joins the Survey.—Thomas Colby was born in 1784, and received his commission, as a Second-Lieutenant in the Royal Engineers, on the 21st December, 1801, being then just over 17 years old. His commission is signed by George III and countersigned by Lord Chatham, Master General of His Majesty's Ordnance. A short account of Colby's career will be given later on; meanwhile it is sufficient to say that it is to Colby that the Survey owes its present organization, and to Colby, also, were due most of the methods which were in use for nearly a century. It was, indeed, Colby who eventually gave the Survey its distinctive character. Three weeks after being commissioned he was appointed to the Survey by the following minute, addressed to Major Mudge, from the Chief Engineer's office, Westminster:—

12th January, 1802.

SIR,

I am directed by Lt.-General Morse to acquaint you that Second-Lieutenant Thomas Colby, of the Corps of Royal Engineers, is ordered to put himself under your command to be employed upon the Trigonometrical Survey.

I am Sir,

Your most obedient humble servant,

JOHN ROWLEY.

Major Mudge, &c., &c.

Colby soon showed his capacity, and, even as a mere lad, he was entrusted by Mudge with a large share of the work. When, in 1809, Mudge was appointed Lieutenant-Governor of the Royal Military Academy, he left the detailed conduct of the operations largely to Colby, who was then aged twenty-five; and still more of the work devolved on Colby when his chief was, in 1810, given the additional appointment of Superintendent of the College at Addiscombe. The arrangement was probably on the whole, a good one. The larger matters remained under Mudge's control, but Mudge seems to have, rightly, left the actual superintendence and almost all personal work to Colby, who was too young to act effectively with the chiefs of the Board of Ordnance. The position was well known to the

friends of both officers. Thus, Olinthus Gregory, Professor of Mathematics at the R.M.A., writing to Colby shortly after Mudge's death in 1820, says, the Survey "has been for so many years conducted and carried on so entirely by yourself, that I should have thought that the Master General would have settled the appointment the next day." But until 1809 Mudge worked in the field as well as in the office. The relations between the old man and the young were always most friendly; the letters which passed between the two show complete understanding and co-operation.

It is curious that Mudge should have been effectively in charge for the seven years that Williams was nominally the Director; and that, for the last ten years of Mudge's life he should have been obliged, in his turn, by pressure of other duties, to hand over much of the work to Colby.

Progress of the Work, 1800-09.— In the third and last volume of the *Account of the Trigonometrical Survey* will be found a description of the operations from 1800 to 1809. The triangulation was continued with great rapidity, the two 3-ft. theodolites, and one 18-inch theodolite being used. The angles were observed by Mudge, Colby, Woolcot and Gardner.

By the end of 1809 the triangulation of the whole of England and Wales had been completed, except for the counties of Lincoln, Norfolk and Suffolk, and this operation included not only the main, or principal, triangles, but also the secondary triangles required for the "interior" survey.

When tested by the later triangulation the old work of this period stands well as regards the bases, but not so well with respect to the observed angles. It was found that there was an error of about 170 feet in the arc measured between Dunnose and Clifton, a distance of 196 miles; that is to say there was a linear error of about 1 in 6000. This is larger than Mudge expected, for he stated that he thought it unlikely that there was an error of as much as 100 feet, or say 1 in 10,000. But the matter is not now of any importance. It is clear that the work was of ample accuracy for the one-inch map, and it should be understood that the whole triangulation was recast some forty or fifty years later. In fact, the old angles at only six stations were used by Clarke in his reduction of 1858. We need, therefore, only consider Mudge's work with reference to the immediate purpose that he had in view, and for this purpose the work was more than sufficiently exact.

In the year 1806 a base, about $4\frac{1}{2}$ miles long, was measured, by Colby and Woolcot, on Rhuddlan Marsh, near St. Asaph. Clarke, writing in 1858, says, "The extremities of the line were marked, as at Misterton Carr, with blocks of wood, but of these unfortunately every trace has been lost."

Heights of the Hills.—An interesting feature of the work of these years was the calculation of the heights of about three hundred hills scattered over England and Wales. The "low water mark" was used as the datum, so that the heights are not directly comparable with modern values. It is stated that "in deriving the numbers expressing the heights, the several differences have been mingled together, and the means always taken." The results were fairly accordant; two independent values of the same height differed, as a rule, by some 6 or 7 feet. *Sca Fell* came out 3166; modern value, 3162; but the old value should have some feet taken from it to allow for the difference of datum. *Skiddaw*, old value 3022; new value, 3053. *Cader Idris*, old, 2914; new, 2927. *Leith Hill*, old, 993; new, 965. *The Wrekin*, 1320 and 1335; and so on. Anyway, for the first time, the public had available fairly good values for the heights of many British hills; sufficiently good, no doubt, in most cases, to correct the exaggerations of local patriotism. But none of Mudge's heights remain on the present day maps.

The Account of the Trigonometrical Survey.—The third volume of this account, which brings the operation up to the end of 1809, was published by W. Faden in 1811. It is much to be regretted that no further volumes were issued. After this date the history of the Survey must be sought in memoirs and private letters, and in technical publications, such as the Lough Foyle Base of 1827, the Latitude Observations of 1842-50, and so on.

In later years we come to the official Annual Reports, which were presented to Parliament and published. But these, for a long period of years, became dull and colourless to the last degree. The first of these reports was not issued, moreover, until 1856. So, in order to find out what was really going on from 1810 to that date, we are driven, perhaps, not unwillingly, to study Portlock's Memoir of Colby, Flint's Memoirs of the Mudge Family, and the correspondence, preserved in the Colby collection, between Mudge, Colby and their contemporaries.

Letters from Mudge.—Thirty-three letters, written by Mudge, have been preserved in the Colby collection; and of these all but one are addressed to Colby. The one exception is a letter to Lieutenant-Colonel Hadden, R.A., who was Colby's uncle, (his mother's brother). Hadden was a distinguished soldier who had served in North America. In 1793 he became secretary to the Duke of Richmond, Master General of the Ordnance; he afterwards served as Adjutant-General in Portugal, and, finally, became Surveyor-General of the Ordnance and a Major-General. Mudge's letter to him is dated, Drawing Room, Tower, 14th January, 1802, and runs thus:—

"I send you your copy of the Kent Map, and will transmit others when I obtain a fresh supply, which will be in a day or two.

Lord Howe I found at the Board on Tuesday. I communicated the wishes of the Master General, as to his presenting me at the Levee, but his Lordship had made an arrangement which called him yesterday out of Town. I therefore made my own way, thro' the aid of the Lord in Waiting, and presented the Map to his Majesty, who, I think, still remains to be informed, that it is *an actual map*, and not a written account similar to the last presented."

On September 5th, 1804, Mudge writes to Colby from Teignmouth :

DEAR COLBY,

As soon as possible, let the direction of the Meridian be observed. For this purpose, Woolcot and yourself must lay your heads together. Two double Azimuths that agree will be sufficient. [*Then follow technical instructions*]. Your letter of the 27th ultimo came to hand today. Thank you Colby for your attention to the Base of Altitude business ; it assures me of your assiduity, and with all the work we have in hand your perseverance will supply the place of my attendance. And farewell, believing me

Ever your friend,

W. MUDGE.

. . . . In observing the star tell Mr. Woolcot not to lean with his arm, or rest his breast on the Cover of the Instrument. Col. Hadden desires to be remembered to you, and that you would, when you write to your Father, send your letters under cover to him.

In another letter, apparently from the Tower of about the same date, he says :—" 500 Great People have been here to-day "

Tower, May 17th, 1805.

DEAR COLBY,

I will immediately procure and send off to Holyhead, an Ephemeris and requisite tables [*Then follow instructions for the observation of a star at elongation*]. You act very properly in waiting my reply to the question you propose, in regard to the possibility of certain [changes] being introduced into our work from the circumstance you mention. I certainly do think that we should be very guarded in admitting new *succedanea* in our operations. There has been too much of it of late, but the fault was Woolcot's, not yours. If the Karn of Stones, or the heap upon it, be a fair cone, at least tolerably so, on this occasion have recourse to it instead of a P[ole]

Dear Colby,

Ever yours sincerely, W. MUDGE.

Cockington, July 9th, 1805.

MY DEAR COLBY,

. Having got *out* of the Isle of Anglesea, get as far *away* from it as possible. Steer off towards Chester. Don't make a practice of going to all the three points of every triangle, if observations made at two of them will be sufficient. Work round spires, staffs on mountains or any other proper objects, that the Survey may get on rapidly.

. . . . I shall be back again in 7 or 8 days. I am just now going to Mintern, or Revel's Hill in Dorsetshire. I shall not send Woolcot to you now. . . . Glad I am that I have a man with me, who can think and act as you do. . . . I wish you in all things to consult your own will, convenience and happiness, requiring you only to be punctual in writing me about all you do

The Irish Military Survey Bill has no reference to us!

There is now a gap in the sequence of letters, and the next one preserved was written six years later. The year 1811 was a trying one for Mudge. He gave evidence before Commissioners that the total expense of the Survey, during the past 20 years, had been somewhat more than £50,000. It would appear that the atmosphere of the Honourable Board was not, at this time, a very friendly one. But Archdeacon Flint quotes a letter from the Horse Guards, expressing admiration for "those exertions and talents, by which that art [of Topography] has in elegance and accuracy been brought in this country, to a degree of perfection surpassing that of any other country in Europe."

At the same time "an order came from the Master General to withhold every map from the public."

On 27th July, 1811, Mudge writes to Colby from Brighton:—

"You will hear with sorrow and with surprise that ten days have elapsed since I requested the Master General and Board permission to put the Account in the hands of Mr. Faden without receiving any answer to my Letter. This silence augurs mischief! . . . though checked as I am at the Trigonometrical Plough, perhaps it matters but little whether I turn up the Soil or leave it in Sod. I am quite dispirited and dismayed." . . .

In August and September of 1811 Mudge's work was subjected to a Military Enquiry. He writes on the 2nd September:—

. . . "Had it not been for the *Military Commissioners* I should long since have been on the search after you. . . . See you not the two words, *Military Commissioners*, aye, see you them not!—I have been before them. I cannot tell whether they imagine me to be a rogue or not, but they deal with me exactly as if they thought so. They gave me not a moment's notice scarcely for preparation, taking me literally at the *ground hop* on my return to Town from Brighton. They examined me in the twofold capacity of Lt.-Governor of the Academy and Director of the Survey. I have my own opinion of their talents, severally and jointly. I believe they thought some great secrets were hidden and that torture would be necessary to find them out. Soon, however, were they undeceived, for I very shortly told them that the day was come which I had long looked forward to with pleasure, and that I appeared before them rather with the hope of being allowed to assist them in their enquiries than as a subject for examination, for that I knew well, without my assistance, their enquiries never could suffice to satisfy the Public or myself. On this

Principle, therefore, the gentlemen composing the Board have had laid before them an account of every shilling of money expended on the Survey since the year 1791, amounting to something more than £52,000. That is to say, the Engraving, the interior Surveying, the Trigonometrical Survey, travelling, etc., amounts to that sum. From these accounts it will appear that the average expence of the Total Survey since 1800 has been about £4,300 per annum and the average expence of the mere T. Survey, included in that sum, about £1000 per annum, our salaries, with Mr. Woolcot's and Mr. Gardner's, with travelling included. So you see the anonymous author has told a d—d lie in stating that the Expences of the Survey has exceeded £10,000 per annum. I suppose the Commissioners must, and I dare say they will, make some good natured observations in their Report; they will state more particularly that the Engravers have no check on them after the hours of regular work. I care not, however, because I am conscious that, to the best of my abilities, mental and corporeal, I have discharged every trust deputed to me in this undertaking like an honest man.

I devote this month to travelling among the Surveyors, and I shall beg of you to meet me at Chepstow."

Ever in truth and sincerity, if that be not tautology,

Believe me, your sincere,

W. MUDGE.

Another letter on the same subject :—

Royal Arsenal, Woolwich.

October 1st, 1811.

. . . I know not that it would be objectionable to publish it at Charing Cross, so that I can have no scruple to let the contents of my Letter float on the Sea of Chance The Board first examined me on the score of the Academy, and the examination impressed me with the opinion, which I believe to be true, viz., that they had got at a pretty accurate knowledge of the state of the Establishment at the time I came to it, and what it was at the hour of examination. . . . In respect to the Survey I was examined on all the essentials of the operation, and finally asked the pointed question of its utility and continuation. I did my best to satisfy them in the first point, and gave for my answer in the second, that the Trigonometrical Survey of England being completed, save and except a small part of the eastern side of it, to complete which little time would be required, I thought the Survey of Scotland, in the mere triangular part, would not take more than 5 years, and that it was my intention to commence the Survey of that part of the Kingdom next year—our destination for 1812 is therefore fixed—The *Total* expence of the Trigonometrical Survey itself *ab origine* 1790=21 years, was stated at £21,000. The Commissioners considered this sum as large, and asked if they could be furnished with all the particulars constituting that expence? I told them certainly, and *instantly* they had these further sums given, viz.:

£25,347 7s. 7d. for the interior Survey, Travelling, &c.

and £7,817 18s. od. for the Engraving. . . .

£54,165 5s. 7d. being the total expence, which, divided by 20, the number of years £2208* for a mean annual expence ; but the present mean is nearly £4,416 the present annual expence. I dare to say the Commissioners will animadvert, pretty strongly, on the apparent magnitude of this sum ; but everybody I have shown it to thinks the sum a fleabite ; in fact so it is a fleabite, and I myself thought it had been more I am certain they were strongly impressed with an idea of the extreme accuracy of the work, but I think the Commissioners will stab at my plurality of offices. My last moments, whenever they do come, will not be embittered with the recollection of any of my sins of commission or omission as touching the Survey. The Work† is approved of and sells well. All publication of future works is stopped."

So the Board of Ordnance, in its wisdom, saw fit to stop the further publication of adequate accounts of the work of the Survey ; a prohibition of which the effects remain to this day. For the Annual Reports which were eventually issued (but not till 1856) are poor things compared with the reports issued by other great surveys, and are but meagre outlines of the work accomplished, though they are better than nothing. Mudge, after 1811, had to content himself with nothing. Lord Mulgrave was the Master General responsible.

Mudge, and the Survey, survived the encounter with the Commissioners, and the work went on. On the 9th September, 1813, he writes :—

" I am very desirous that you should immediately read the review of Major Lambton's Papers in the Asiatic Searches, giving an account of his Trigonometrical operations in India, which review is to be found in the last number of the Edinburgh Castigator ; it is undoubtedly done by Playfair, who had us in his eye all the way through, and has ended his critique with the strongest compliment that could have been paid to the Surveyors in this country Mr. Playfair is a man of great natural sagacity and much acquired information.

" You will now hear with great satisfaction the probability of my returning with you to the North next Spring to finish our operations, for my health is much restored, and though I write by the hand of another, yet I am in many respects better than I have been for some years, and this brings in my mind how happy I am to account myself, that Providence has placed to my hand so able and so firm a friend as you are.....

Royal Arsenal,

22nd September, 1813.

DEAR COLBY,

I have written to the Board desiring that orders may be sent to the storekeeper at Fort George to receive the Sector and Apparatus. You, of course, direct your steps due south, and will perhaps arrive at your old

* A slip of Mudge's, it should, of course, be £2708.

† Volume III of the *Account of the Trigonometrical Survey*, published by Faden in 1811.

quarters in the Tower sometime in the middle of October. You are very much wanted, for what with laying down of points, settling of edges, reconciling differences, and setting out new Work, there is abundant to engage you. Mr. Gardner will, of course, come with you General Hadden was with me yesterday, and also Mrs. Hadden, after putting Brother Martin into his grave. Poor old Gentleman, 97 years after he was born he bid adieu to this World of tears and repentance, and now lies with the mouldering remains of all the Carpulets in Plumstead Church Yard The public papers will have made you acquainted with the loss of my poor friend Fletcher,* a loss indeed, both to the Public and to his Family, but this comes of Volunteering and looking plump into the Cannon's Mouth. Collyer fell upon the top of the breach killed, his place was directly supplied by Mr. Marshall, who instantly dropped wounded; the third, Capt. Rhodes, immediately repaired to the spot and was also instantly killed, a fourth then mounted the breach and happily survived; really I think hereafter the Corps of Engineers should be looked upon as belonging to *Undertakers* as well as to Carpenters and Joiners, and have the Death's Head and bones upon their Buttons by way of a *Memento Mori*. It is a nice Corps for Promotion, but excessively selfish, for it has absorbed all that once belonged to the Artillery."

In the same year, 1813, Wordsworth wrote a poem on the subject of one of Mudge's experiences on the mountain of Black Comb in Cumberland. "Written with a slate pencil on a stone, on the side of the Mountain of Black Comb—

Stay, bold Adventurer; rest awhile thy limbs
On this commodious Seat! for much remains
Of hard ascent before thou reach the top
Of this huge Eminence—from blackness named,
And, to far-travelled storms of sea and land,
A favourite spot of tournament and war!

Know
That on the summit whither thou art bound
A geographic Labourer pitched his tent,
With books supplied and instruments of art,
To measure height and distance; lonely task,
Week after week pursued!

....Once, while there he plied his studious work,
Within that canvas Dwelling, colours, lines,
And the whole surface of the outspread map,
Became invisible total gloom
In which he sate alone, with unclosed eyes
Upon the blinded mountain's silent top!"

* Sir Richard Fletcher, killed on 31st August, 1813, at San Sebastian. He had married Mudge's sister, Elizabeth.

The Beginnings of the Geological Survey.—Mudge, writing to Colby on the 16th May, 1814, says,

“ On Friday I received a letter from Col. Chapman, grounded on a very good and scientific Representation to the Master General, desiring to know whether or not a Mineralogical and Geological Surveyor would not be exceedingly useful to me, as affording means of making those observations in those branches of human knowledge that might help to account for those extraordinary Anomalies which have of late so inconveniently hung round our operations. The Master General at the same time desiring to be informed whether, if such were my opinion, Dr. McCulloch would not be a very good person for the place. My answer was, as you may suppose it was, affirmative all the way through, and I do in consequence expect to have Dr. McCulloch's appointment nominated to me before the present week shall finish its course.”

The idea was, that Dr. MacCulloch (as his name is usually spelt), should be able to point out where and what abnormal deflections of the plumbline were likely to occur; with a view to avoiding stations for the zenith sector where large deflections might be expected. The zenith sector observations being required for the determination of the meridian curvatures, which were themselves required in the construction of the one-inch map.

John MacCulloch was born in 1773, in Guernsey, and studied medicine in Edinburgh. In 1811 he gave up his practice and devoted himself to the geological investigation of Scotland. In May, 1814, he was appointed geologist to the Trigonometrical Survey. In 1826 he was instructed by the Treasury to prepare a geological map of Scotland. “ This large undertaking was completed in 1834. There were, however, no detailed topographical maps of Scotland available at that time, and MacCulloch had to enter the geological colours on the meagre topographical basis of the Arrowsmith map. MacCulloch's map was published posthumously in 1840.”* A competent observer, Mr. J. Jardine, writing to Colby in December, 1819, expresses his astonishment at the extent of MacCulloch's work and its accuracy. “ No person but a man of iron like yourself could have gone over such an extent of rugged country with so much minute accuracy.”

MacCulloch's death occurred in 1835, and was caused by a carriage accident.

Lyell, in an address to the Geological Society of the 19th February, 1836, says, “ The map of Scotland, by Dr. MacCulloch, which has been so long and impatiently expected, is at length on the eve of publication. But at the moment when I can announce this

* Zittel's *History of Geology and Palæontology*, translated by M. Ogilvie-Gordon, p. 113. The writer is indebted to Mr. J. A. Howe, of the Geological Survey, for this reference.

welcome intelligence, we have to deplore the sudden loss of this distinguished philosopher." Lyell speaks of a want of condensation and clearness in MacCulloch's style and "a disposition to neglect or speak slightly of the labours of others." MacCulloch seems to have been troubled with continual ill-health, and this made him difficult to get on with. His work, is, however, of importance in the history of geology, and Lyell said that he received more instruction from MacCulloch's labours in geology than he had from those of any then-living geologist.

The rest of the early history of official geology in this country may be briefly summarized. MacCulloch himself wrote *Memoirs to H. M. Treasury respecting a Geological Survey of Scotland*, the forwarding letter being dated July, 28, 1834. These memoirs were published by Arrowsmith after MacCulloch's death. The writer says that the Board of Ordnance gave him originally two principal tasks; one being to discover a mountain more suitable for the determination of the density of the Earth than Schiehallien, and the other the geological investigation of probable attractions of the plumb-bob. There were no accurate maps of Scotland in his day, and he says, with reference to the one-inch Ordnance map of England "It would require but a small geologist indeed to lay down the rocks of any part of England on the Ordnance maps; he is to be envied on whom such a duty may hereafter fall." He also talks about "the geographical surveyors of that splendid work."

In the spring of 1835, the Master General and Board of Ordnance appointed a committee, composed of Lyell, Buckland and Sedgwick, to report upon the desirability of a Geological Survey of England. "The enlightened views of the Board of Ordnance were warmly seconded by the present Chancellor of the Exchequer, and a grant was obtained from the Treasury to defray the additional expense which will be incurred in colouring geologically the Ordnance county maps." But, for some years before this was sanctioned, H. T. De la Beche had been mapping, at his own expense, the geological structure of Devon and Cornwall. He applied to the Government for recognition and assistance, and his application was warmly supported by Colby, who had long encouraged the Ordnance Surveyors to keep a record of geological observations. De la Beche represented that his work would be much more efficiently carried out if joined with the Trigonometrical Survey. The sum allowed for the Geological Survey was £300 a year, most of the expenses still falling on De la Beche. A room was assigned to him for the collection of geological specimens in Craig's Court, Charing Cross—an address once very familiar to R.A. and R.E. officers—and De la Beche was appointed Director of the infant museum—with no salary.

In 1845 the geological staff, which had meanwhile been increased, was transferred from the Board of Ordnance to the office of Woods

and Forests, and, thereafter, the only connection between the Geological Survey and the Ordnance Survey was that the latter continued to print, colour and publish, the maps of the former. De la Beche remained in charge of the Geological Survey until 1855, when he died, and was succeeded by Sir Roderick Murchison.

The friend and biographer of Sir Roderick, the late Sir Archibald Geikie, who was Director of the Geological Survey from 1881 to 1901, wrote in his recently published autobiography*: "During the first ten years of its existence, [1835-1845], the Geological Survey was a branch of the Board of Ordnance. Its officers wore a dark blue official uniform. But a tight-fitting, well buttoned frock coat could only be an inconvenient garment for the rough scrambling and climbing life of a field-geologist. It was accordingly at once discarded when the Survey in 1845 was placed under the office of Woods and Forests."

One would like to know who insisted upon the dark blue frock coat. It does not seem the sort of thing that Colby was likely to do. Some of the brass buttons that adorned the coat, bearing a device of crossed hammers, are still in existence.

Don Rodriguez.—There is a wearisome small business which must be recorded, because it occupied a good deal of Mudge's time and exercised his patience, but in itself was a matter of little importance. Don J. Rodriguez was permitted to publish, in the *Philosophical Transactions* of 1812, a paper in which he explained the anomalies in Mudge's arc from Dunnose to Clifton as being caused by errors in the latitudes derived from Ramsden's zenith sector. Mudge was convinced that this was not the true explanation. But some scientific men accepted the Don's view and Mudge was naturally concerned to defend the accuracy of his work. In his letter to Colby of the 16th May, 1814, he writes:—"I should have derived infinite satisfaction from the Zenith Sector being this year used instead of the Circular Instrument, and am sure I cannot see why it should not be so used, for I should in that case be enabled the sooner to put up the Zenith Sector on Arbury Hill, which I have promised to do, and certainly will do, not indeed to please Don Rodriguez, for he at length has given up, but to vindicate the memory of Ramsden and ourselves. The Reviewers, you will find, have, I am sure, without my knowing anything about it, made their *amende honorable* and the Honorable Society are likewise concerned that they have given any Countenance to Don Rodriguez."

It does not appear that Arbury Hill was ever, as a fact, revisited for the purpose. But there are three stations in the triangulation of the United Kingdom at which observations for latitude were taken

* *A Long Life's Work.* Sir Archibald Geikie, O.M., K.C.B., F.R.S. p. 47.

with Ramsden's zenith sector, and forty years afterwards with Airy's zenith sector. These three stations are : Dunnose, Cowhythe and Balta. The difference between the resulting latitudes were found to be: $0''.01$, $0''.11$, and $0''.09$ —an ample vindication of the excellence of Ramsden's instrument. And there we may leave the matter.

The Work of the Survey from 1810 to 1820.—During these years the triangulation was pushed on into Scotland, the observations being made by Colby and Gardner. Thus we find that, in 1814, Colby observed from 10 stations in Scotland ; in the latter part of 1815 the observations were chiefly carried out by Gardner, because Colby was then called to the Tower. There are records of the Scottish triangulation being carried on by these two in the years 1816 to 1819 inclusive.

The zenith sector was set up at Kellie Law in 1813, at Cowhythe in the same year, and at Balta in 1817, Colby and Gardner being the observers.

In 1817, also, Colby and Gardner measured a base at Belhelvie, near Aberdeen. Its length was 26,515.65 feet of Ramsden's scale, or 26517.53 feet of the final Ordnance standard (O_1). As tested by the connection with the later triangulation, reduced by Clarke, the discrepancy was about 1 in 110,000. This base was measured with Ramsden's two 100-ft. chains and one 50-ft. chain.

The detail survey went on in England. "Surveyors belonging to the corps of Surveyors and Draughtsmen were now employed in various parts of the country, by permission of the Chief Engineer (Inspector General of Fortifications), who was the official head of the corps, and they received, besides their military pay as warrant officers, 32s. 6d. per square mile, for all the work they surveyed and plotted on a scale of two inches to the mile. These plots were reduced at the Map Office to plans on a scale of one inch to a mile and traces from these prepared for the use of the engravers."* Before Mudge's death in April, 1820, substantial progress had been made in the production of the one-inch map. 37 sheets had been printed, with regular sheet-lines, ignoring the county boundaries. The sheets varied in length from east to west, the largest being 35 inches long ; from north to south they measured 23 inches. The area covered was the whole of the South of England, up to a line running roughly through Bath, Oxford, Hertford and Ipswich. The sheet covering Pembrokeshire was also printed. And of course, many sheets were in the hands of the engravers.

* *Memoirs of Major-General Colby.* By Lt.-Col. Portlock, R.E., F.R.S.

Some more letters from Mudge:—

Royal Arsenal,
16th May, 1814.

We have had so much trouble here with shewing the lions to one Duchess, that the trouble to shew them to two Emperors and one King, if it be determined by the Rules of Common Arithmetic, I look for it as certain that Bedlam will be well stocked.

Royal Arsenal,
14th August, 1815.

. . . of Dr. McCulloch I know nothing and have in fact heard as little as I know—your sentiments on our Union with his proceedings are precisely the same as mine. Mr. Hyett has completed his second Survey of the St. Alban's District, and certainly the result would augur that we have blamed him beyond his deserts. Mr. Yeakell seems to break [up] with great rapidity both as his strength of Eye and general health is concerned. . . . I find it necessary to look very close into his work. . . .

Royal Arsenal,
September 21st, 1815.

On account of the advanced season of the year and still more on account of my long continued indisposition . . I beg you will *immediately* close your operations and return to London.

Royal Arsenal,
27th January, 1816.

. . . .When I get Mr. Crocker's Edge, Mr. Budgen's plan, and Mr. Stanley's plan, the whole should be sent to the office, or rather taken there by myself that a fair view of the whole transaction may be laid before the General [*i.e.*, the I.G.F.].

5th February, 1816.

. . . .I want to cut off the surveying attendants on the Surveyors and that as quickly as possible.

29th February, 1816.

I . . . was informed that the Austrian Arch Dukes wanted to see everything connected with the Survey, therefore let Mr. Yeakel look out all such plans as it may be proper to show them not neglecting the Isle of Wight and Kent plans. . . . Tomorrow I go to Addiscombe on particular business.

Royal Military Academy,
2nd September, 1816.

. . . .It is my desire not to have more of the public money in my Hands than is actually wanted. . . I believe . . that I have more difficulties thrown in my way as to the progress of the map making by Ignorance, Avarice, and Cupidity than you have by the intervention of Mountains, Morasses with all the local difficulties peculiar to Scotland put together. . . It will, however, please you in understanding that the Work is most highly approved of and esteemed as exceedingly accurate.

10th September, 1816.

I do not imagine under all the difficulties which seem to attend the Northern Survey that the Business of another station can be achieved this year, and if so the conclusion of your operations will be found on Cairnsmuir.

Royal Arsenal,
24th December, 1816.

I wrote M. Biot yesterday, and sent him a sketch of the Triangles Mr. Gardner did for me with some but not many observations touching the best way of proceeding next Year. I dare say I shall hear from him in reply and now I beg you will be so good as to get Mr. Gardner to do for me as quickly as he possibly can another Tracing of the Triangles with the Meridian running up from Dunnose as well as Black Down, and I shall be very glad if I can be supplied with it this week. I came downstairs for the first time to-day consoling myself with my good luck in not being prisoner to my Bedroom longer than I have been. . . I have sent my son [Lieut. Richard Mudge] to Shrewsbury to look after Mr. Stevens' Work.

West European Arc of Meridian.—In the year 1816 the project of extending northwards the European Arc of Meridian, which already stretched the whole length of France, and had been continued into Spain, was discussed on both sides of the Channel. Roy's cross-Channel connection amply sufficed for the purpose of joining the two national surveys, and the chief matter which required decision was the selection of the terminal point of the arc in Great Britain. At first the French were inclined to support Yarmouth (in Norfolk), as suited for the purpose; but eventually better counsels prevailed, and the obvious scheme of using the triangulation of Great Britain to its fullest extent was adopted, and the terminal point was fixed in the Shetland Islands.

Sometime early in 1816, Arago wrote thus to Mudge:—

" La lettre que vous m'avez fait l'honneur de m'écrire a beaucoup ajouté aux regrets que j'avais déjà de ne vous avoir pas été présenté le jour de mon voyage à Woolwich. J'avais le plus grand désir de m'entretenir avec vous de la belle entreprise que vous dirigez avec tout de succès Le seul moyen de me dédommager sera, Monsieur, de me permettre de vous communiquer par écrit quelques idées qui ont été souvent discutées dans le Bureau de longitudes de Paris, sur la liaison qu'on peut établir entre vos mesures et celles que nous avons exécutées en France et en Espagne.

On the 19th October, 1816, Arago again writes to Mudge:—

J'ai reçu la lettre que vous m'avez fait l'honneur de m'écrire et des aujourd'hui je vais mettre votre obligeance à contribution; je vous demanderais Si Yarmouth est déjà lié à la chaîne principale de vos triangles et s'il est entré dans votre plan de faire mesurer la latitude de cette station avec assez de soin pour qu'on puisse en faire le point de départ d'une Ligne méridienne qui se terminerait à Formentera. M. Laplace, qui m'a chargé de vous présenter des complimens, tiendrait beaucoup à l'exécution de ce projet; il verrait dans l'arc compris entre Yarmouth et Formentera, le moyen de trouver avec une extrême précision la Valeur D'un degré de Latitude pour le 45^{me} degré. Cette opération aurait cet avantage précieux d'appartenir également à l'Angleterre et à la France et servirait, peut-être, un jour à établir un système uniforme de Poids et Mesures."

Arago goes on to say that the Institute had elected Mudge "un de ses correspondans dans la Section d'Astronomie." Laplace, on the 21st March, 1817, made a speech in the Chambre des Pairs on the subject of the measurement of the West European Arc ; in this speech he alluded to Mudge as follows : Le Colonel Mudge, qui lève avec autant d'habilité que de zèle les plans de l'Angleterre et de l'Ecosse, doit se réunir aux savants français et concourir avec eux au prolongement de notre méridienne.

Jean Baptiste Biot was the Frenchman selected to work with Mudge and Colby ; Arago, unfortunately, was not able to come over to England at a suitable time. Biot (1774-1862), was a friend of Laplace and Arago, a distinguished member of the French Institute, and a man of all-round attainments. But he and Colby did not manage to hit it off. Biot was ten years older than Colby, and it is possible that he did not realise that the latter had for many years been in effective charge of the operations of the survey. Biot arrived in England in May 1817, and was hospitably received. On the 20th of that month, Mudge writes :—" I have been travelling in a chaise with M. Biot, who speaks English as imperfectly as I do French." Mudge had resolved to take charge of the work, but alas ! ill-health prevented his getting further than Edinburgh. He writes from Leith on the 7th June, 1817, to Colby, who was then at Aberdeen:—

" I came here with M. Biot upwards of a fortnight since and have been busily occupied in erecting an observatory, preparing for the clock, and adjusting the Circle of repetition. . . I am chained up here something like a wild beast against my will, finding it impossible to leave M. Biot, whom I perceive to be a very able man and a very diligent observer. . . Dr. Gregory will come out for the holidays and perhaps be at Aberdeen towards the end of the month. Mr. Thomas, Commander of H.M.B. Investigator, goes round to Aberdeen tomorrow to have an interview with you."

Ultimately, the scheme agreed to was, that Colby, Gregory and Gardner should take Ramsden's zenith sector to some station in the Shetland Islands and observe for latitude ; that Biot, accompanied by Richard Mudge, should observe a latitude with the French repeating instrument at the same station, and should also take pendulum observations for the determination of gravity ; that the British survey should connect the Shetland station with the British triangulation, through the Orkneys and Foula.

A letter from Laplace to Mudge has been preserved. It runs as follows :—

Paris, le 4 juillet, 1817.

MONSIEUR,

Je commence par vous remercier de la bienveillance avec laquelle vous avez accueilli mon idée de joindre Yarmouth à la méridienne de France, en voulant bien coopérer vous même à cette jonction.

Mais je vois par votre lettre qu'en étendant jusqu'aux isles Shetland vos opérations, et vous rapprochant ainsi de cette meridienne, vous croyez que l'on peut sans erreur sensible joindre votre arc de meridiem au notre et qu'alors la station de Yarmouth devient inutile ; je pense entierement comme vous, Monsieur, et je suis persuadé que l'extension de l'arc du meridiem jusqu'au soixantième degré de latitude est plus que suffisante pour compenser l'inconvenant qui pourrait resulter d'une petite dissemblance des meridiens aussi voisins. . . .

Je me felicite, Monsieur, de l'occasion que m'offre cette circonstance pour vous témoigner toute ma reconnaissance, et l'estime particulière que vos travaux importants m'ont depuis longtemps inspirée.

Well, the execution of this scheme was largely spoilt by the fact that Colby and Biot could not agree ; Mudge not being there to take charge and compose differences. Portlock says that " Dr. Gregory attached himself to Captain Colby ; and whilst the latter disliked and distrusted Biot, he, Biot, detested Dr. Gregory. Don Rodriguez, who had been so severely attacked by Dr. Gregory, had been the associate and friend of Biot in the triangulation of France and Spain." Richard Mudge in after years said that " it was fated that an eternal frost should separate Colby and Biot."

In the end Colby set up his instruments at Balta, and Biot his instruments on Unst. Mudge writes to Colby, " One great disadvantage attending your removal from M. Biot is that a comparison cannot be made between the results of observations. . . . with the sector and circle of repetition ; this is a very great misfortune " ; and again, " I have never ceased to deplore, with the keenest recollection, the happiness that I thought before me nipped in the bud, and I sent home, as it were, invalided."

There is no need to go into the details of the operations ; they must not be looked upon as wasted, but as somewhat injured by the want of co-operation. The coolness between Colby and Biot never extended to Arago, nor did it affect further co-operation. In November, 1817, Arago and Humboldt, accompanied by Biot, came to England with two pendulums, which were swung at Greenwich in the presence of Pond, the Astronomer Royal. Arago, Humboldt, Biot and Colby all met at Mudge's house in the Arsenal during the same month. Late in 1818, Mudge and Colby took Ramsden's sector to Dunkirk and observed a latitude with it, at the request of Arago and Biot ; but " it is certain that the desire of Colonel Mudge, to bring the sector and repeating circle into direct comparison with each other, was not even gratified at Dunkirk." No blame, with regard to the Shetland affair, was ever attached, by anyone, to Mudge, who remained on friendly terms with all concerned.

Let us end this story of the Shetland work on a more cheerful note ;—

Captain A. Thomas, R.N., to Colby, H.M.B. Investigator, Balta Sound,
26th August, 1817.

"I have sent you by the Jolly Boat two gallons of rum and thirty pounds of Ship Biscuit, now in return you will be so good as to send me on board the same man that was on Yell and Fetlar with me, and to-morrow evening the staff will be on Ronas Hill; and should there be any westing in the wind the day after tomorrow, the staff will be on Faul Isle. . ."

Progress of the Work from 1818 to 1820.

Mudge to Colby, April 25, 1818.

"I have a great deal to do one way or the other, so that I shall not be at the Tower until towards the end of the week, but if you will take a run down we can arrange anything that may appear pressing to you. I attended Council of Royal Society on Thursday, on business closely connected with the Survey, of which I can say nothing more at present excepting that the Pendulum is to be carried along our arch under Captain Kater."

Royal Arsenal, Woolwich,

1st May, 1818.

. . . "I was yesterday at the Committee Somerset House, when it was determined that Captain Kater should go on the Meridional Line from Dunnose to Shetland, visiting the two extremities of the Arc and three intermediate stations, and Edinburgh one of them."

Royal Military Academy,

1st September, 1818.

"The account you give of your operations is very satisfactory, and we have another proof, if another proof were wanted, of your zeal and activity. When the state of the Work shall be known to the public they will have a just means of estimating your talents which will receive their deserved reward. The Frome sheet is struck off with the Hills finished. I have been all over that quarter with the Map in my Hand and find the work excellently done. Sir Rd. Hoare, to whom I gave a proof for correction, is delighted with the work and particularly with the antiquities, to which all the persons employed on the Survey of that Quarter have paid particular attention. . . . The Admiralty, with Mr. Croker, took down the Hampshire Survey when they settled in the South the new Telegraph line. Mr. Croker told Captain Hurd that without it they could have done nothing. Faden also says that the reputation of the Work increases daily."

In the same letter he points out to Colby the necessity of accepting the French offer to take the sector to Dunkirk.

"I do say that tho' you have no reason whatever to be pleased with Biot, and God knows I have just as little, yet I trust you will see with me the actual necessity of our concluding the work of this year in France; I feel that by so doing I shall conclude my labours honourably. . . Captain Thomas in the Investigator will take us to Dunkirk."

14th September, 1818.

... "I am to-morrow to be at the Admiralty with Mr. Croker, and am truly happy in finding we are firmly supported in that quarter. ... The work of reduction, the deadly work of reduction, is going on swimmingly. [The Ordnance estimates were being reduced and the Artillery cut down]. ... I am, thank God, perfectly well and just off a journey of 260 miles. P.S.—Mr. Gardner must go over with us."

Royal Arsenal,
21st February, 1819.

"The Duke [of Wellington] has postponed for a little time any consideration of the Scotch Survey, but proposed, when his present business is off his hands, to see whether it cannot be carried on less expensively than the way we propose." The Duke had also complained of imperfections in the one-inch sheet containing Strathfieldsaye and Mudge says, "It is my intention to battle this matter inch by inch. To all appearances I shall

See a great deal more of
His Grace than will be
pleasing.

I am quite depressed under all these considerations and mean without delay to collate all the Field Work in hand, that the vessel may be under proper Trim when the Storm comes on. Of the little time I have before me I must make all the use I can. My opinion is that the Quarter-Master-General's Department and Arrowsmiths are at the bottom of the whole of it."

That is the last letter preserved in the Colby collection from this old chief of the Survey. He had now not much more than a year to live. He died, as stated above, on the 17th April, 1820.

Robert Dawson, who had worked under Mudge since 1802, and knew him well, wrote to Colby on hearing the news:—

"Alas! the connection of 18 years is dissolved and we are left in sorrow and reflection. The General's kind and amiable disposition, his mildness of temper, gentleness of command, and many marks of attachment and regard given to me particularly, and evidently always ready for his Friends, have created and nourished a Love for him in my heart, which will ever be the first impulse with which I shall cherish his memory."

Portlock, who was a cadet when Mudge was Lieut-Governor of the R.M. Academy, says in his memoir, "The present writer, when at the Academy, enjoyed the occasional privilege of visiting at his house, and whilst participating in the friendly hospitality which he bestowed upon his young friends, and which was always distinguished by a warmth and simplicity which made them feel quite at home, even with the Lieutenant-Governor, had ample opportunity of witnessing and appreciating that never-ceasing enthusiasm for his favourite science which he felt in his own heart, and desired on every occasion to instil into the minds and hearts of his young guests."

VI. PROGRESS FROM 1820 to 1825.

DRUMMOND, GARDNER, DAWSON.

Progress of the Survey, 1820-25.—In 1824 a Select Committee of the House of Commons, under the chairmanship of Mr. Spring Rice was appointed to consider the question of a Survey and Valuation of Ireland, and Colby, as Director of the British Survey, gave evidence in March and April of that year. The Ordnance Survey had now been in official existence for thirty-three years, and it appears from Colby's evidence that the triangulation of Great Britain was nearly completed, though it must be noted that many of the stations were subsequently revisited: the latest observations were not made, in fact, until 1853, and most of the angles in Great Britain, used in Clarke's reduction, were observed after 1837. Colby stated that the one-inch map of England and Wales was two-thirds completed in the field. The one-inch map of Scotland had not been begun.

Some of the questions and answers are interesting, for instance :—

" [The Survey of England] was begun upon six inches to a mile? Part of Kent, which was considered of consequence for military purposes, was surveyed upon that scale.

" It was actually protracted upon that scale?—Yes.

" Are there any means now in existence of protracting the surveys you have made in England upon that scale?—No, certainly not; the survey has been made upon the scale of two inches to a mile.

" You could not now protract the survey of England from your field notes upon the scale of six inches to a mile?—Not with the degree of accuracy which that scale would require."

It may be noted that the Committee made use of the term Ordnance Survey, thus: "In the ordnance survey do you distinguish the different descriptions of roads?"

As regards the strength of the department in 1824: "What is the force employed in England and Scotland now?—We have ten officers of Engineers.

" What force have you under them; what is the whole force employed in the survey?—I have ten surveyors under them.

" Is that the whole force?—Yes, the whole force."

It may be supposed that we should add to this number the engravers at the Tower. In the draft of a minute to the Board, written probably by Colby about 1820, it is stated that Mr. Baker

was the principal engraver, and there were three apprentices who were engaged because "much difficulty had been found in procuring a sufficient number of persons already initiated in the art of engraving who were accustomed to the style of accuracy required in the maps." How many other engravers were employed at the Tower is not known. On completion of his apprenticeship, an engraver was paid £2 12s. 6d. a week.

The Peace of 1815 had freed officers for this employment. Lieut. Richard Mudge was appointed to the Survey in 1816; then followed Lieuts. Dawson, Robe, Renny, Captain Gossett and Captain Vetch, in 1819; Lieut. Drummond in 1820 and Lieut. Larcom in 1824.

It is sometimes supposed that, in 1825, the whole personnel of the Survey was transferred to Ireland. Sir Henry James, who was then Director of the Survey, stated in 1859, that, in 1824, the one-inch survey had extended from the Land's End to the boundary of Yorkshire and Lancashire, including the whole of Wales. He went on to say that, "it was then decided that there should be a general valuation of Ireland, and that as a necessary basis for that valuation, there should be a town land survey. . . The whole survey force was then sent to Ireland, and the survey of Great Britain was altogether suspended. We commenced first in the North of Ireland, I myself taking part in the survey."

But this was not quite the case. The office in the Tower was still kept in existence, and some field work was still carried on, in order to keep the engravers at the Tower supplied with material for the one-inch map. Colby was frequently at the Tower. It would appear to be more correct to say that most of the officers and men were transferred to Ireland in 1825, leaving only Captain Mudge in the Tower with a very small staff to deal with the one-inch sheets of England and Wales.

In December, 1822, there came a visitor to the Survey Office in the Tower, whose name is very familiar to most British topographers, namely, Robert Shortrede. All who have painfully interpolated the logarithms of trigonometrical functions, in the absence of their copy of Shortrede, will always recall his name with gratitude, and swear never to go without him again. On the 22nd December, Robert Stevenson, the engineer, wrote the following note to Colby:—"The bearer, Mr. Robert Shortrede, was for some time in my office and now goes to India under the auspices of Sir Walter Scott. He is a very keen mathematician, and I beg to be allowed to give him an opportunity of seeing the extent of the trigonometrical survey in the Drawing Room."

Robert Stevenson, the writer of the note, is justly celebrated as the designer and builder of many lighthouses, notably that on the Bell Rock. But he is, nowadays, even more celebrated as the grandfather of R. L. Stevenson, who was, however, born after

his grandfather's death. In the Colby collection there are many letters from Robert Stevenson, who frequently corresponded with Colby. The little letter above quoted brings into pleasant juxtaposition the names of Sir Walter Scott, Stevenson, Shortrede and Colby—literature, lighthouses and logarithms.

In January, 1823, died that old mentor and friend of the Survey, Dr. Charles Hutton. His son wrote to Colby from 34, Southampton Row, on the 29th of that month :—

“ It is my painful task to inform you that my venerable Parent, your Friend, Dr. Hutton, departed this life on Monday morning, after an illness of several weeks, in the 86th year of his age. It will be pleasing to his numerous friends to learn that he happily retained his mental faculties to the last. So recently as Friday afternoon, he dictated a letter, in reply to a communication which he had received in the morning, soliciting the favor of his opinion as to the form of the Arches, which it would be most advisable to adopt, in the construction of the Bridge proposed to be erected over the Thames, on the removal of the old London Bridge.”

The Survey owed much to Dr. Hutton, who advised the Duke of Richmond to appoint Mudge, and the Duke of Wellington to appoint Colby. It is true that he advised the appointment also of the ineffective Williams ; but, fortunately, no great harm was done, and Hutton could hardly have foreseen that Williams would be a failure.

Dawson, Robe, Renny, Gossett, Vetch, Drummond and Larcom, with Henderson, Murphy, Portlock and James, were all employed on the Irish Survey in the early days. The outstanding men amongst them being Drummond, Larcom and James. Of Larcom and James we shall hear later on, but this may be a convenient place for a brief sketch of Drummond's career.

Thomas Drummond.—Drummond was born in Edinburgh in 1797, and, after passing through the R.M. Academy, was commissioned in the Royal Engineers in 1815. In 1820 he was posted to the Ordnance Survey and remained on that duty until 1831. “ During his winters in London he attended the lectures of Professor W. T. Brand and Michael Faraday at the Royal Institution, and the mention at one of them of the brilliant luminosity of lime when incandescent, suggested to him the employment of the limelight for making distant surveying stations visible. In 1825, when he was assisting Colby in the Irish Survey, his lime-light apparatus (*Drummond light*) was put to a practical test, and enabled observations to be completed between Divis Mountain, near Belfast, and Slieve Snaght, a distance of 67 miles.”*

Trials were also made in the “ long room ” of the Ordnance Office in the Tower, a room which is stated to have had a length of 300 ft.

* *Encyclopædia Britannica. Art. Thomas Drummond.*

The block of buildings of which it formed part was burnt down in 1841. Sir John Herschel thus describes the impression produced when the lime-light was shown on this occasion :—" The common Argand burner and parabolic reflector of a British lighthouse were first exhibited, the room being darkened, and with considerable effect. Fresnel's superb lamp was next disclosed, at whose superior effect the other seemed to dwindle, and showed in a manner quite subordinate. But when the gas began to play, the lime being brought now to its full ignition and the screen suddenly removed, a glare shone forth overpowering, and as it were annihilating both its predecessors. . . . A shout of triumph and of admiration burst from all present." *

In a letter from Colby to his wife, written from the Tower, May 28th, 1830, he says : " To-morrow I go to the visitation at the Royal Observatory, and on Monday we have another exhibition of Drummond's light. We expect Lord Melville, Sir George Cockburn, Sir Thomas Hardy, etc., to be there with the Trinity Board. The last exhibition was quite triumphant. We had a strong shadow by holding the finger before a piece of white paper though the light was 10 miles off !"

This light was first used in practice for the 67 mile ray between Divis and Slieve Snaght ; Drummond was in charge of his light on the latter mountain, which is in Donegal and is over 2,000 ft. high. The party did not begin operations until the end of October, 1825 ; the season was late, and the weather was bitter. Drummond writes from Slieve Snaght on the 28th October : " The tent is now up and in a few minutes the wall round it will be completed, so that we may consider ourselves safe against any storm ; the wind has, fortunately, been Moderate, the fog still continues." Drummond was also using a heliotrope invented by himself. On the 4th November he writes : " This Morning about 9 a.m. the weather cleared, the sun broke out, and I gave you instantly a reflection which kept up till 2.13—with several eclipses intervening. A storm of snow came on at that hour. . . I am just going to make preparations for the camp. . . My tent is blown [down] and I now write from a kind of Cave, formed on the lee side of the Hill. Shall commence with the lamp at $\frac{1}{4}$ past seven."

Drummond suffered much from wind, cold and fog at varying intervals. The tents were sometimes blown down, and it was only with great difficulty that it was possible to direct the light to Divis at night. " The wind encreased to a gale and a sweeping Shower of rain passed over the Mountain. . . What a Villainous Climate. If this evening proves at all possible I shall blaze away till $\frac{1}{4}$ before 11. . . $\frac{1}{4}$ past seven is my first appearance."

* *Dictionary of National Biography. Art. Thomas Drummond.*

On November 5th, writing to Murphy, on Divis : " Give me credit for doing all I can and be thankful for what you get." On the 8th : " Yesterday proved an impossible day. . . Squall succeeded Squall."

On the 9th things were better : " This day promises well ; at 9.18 a.m. the first reflection commenced and Mr. Larcom is now at work—sun bright. . . If this day holds you shall have the lamp every appointed time and I trust our labours will be finished." On the 10th : " I forward you the account of our operations yesterday—if not successful—I despair of success ; there must be a hill in the way."

The operations were successful ; there was no hill in the way. But Drummond did not know this for two or three days. On the 11th at 3 a.m. he writes : " The poor devil who went for the letters has been wandering on the hills since 5 in the evening. . . I look for to-morrow's letters with much anxiety." On 12th November, 1825 : " Of the successful termination of our labours the letters from Divis will already have apprized you. . . . At the last we had nothing remaining but the lamp tent and the walls of the Cooking House. I believe that we should have been compelled to abandon the hill but for the efforts of the men. . . I subjoin a list. . . Corporals Williams, McLaren, Moulton and 9 privates." From Belfast on the 19th : " I arrived here yesterday from my Snaght expedition."

On 12th Lieut. Henderson writes from Divis :—

" On Wednesday I gave you a very hurried intimation of our having seen the reflector. I have still greater pleasure in communicating the result of the light, it was most brilliant. In the evening, when preparing for our observations, one of the watch called out that there was a much stronger light than the one at Randalstown and a little above it ; we immediately turned to that direction and we there saw the light ; it was most brilliant, exceeding in intensity any of the Light Houses. . . . These two days' observations have completely established the advantage of this admirable invention . . . the light . . . can be very easily intersected from its steadiness and brilliancy. . . At night the light was observed on one arc and reverse ; it was taken with all the Light Houses from Corsil to the Lower Light House on the Calf of Man.—Lt. Henderson, Observer."

On the 13th, Henderson writes from Divis :—

" It was most fortunate that the reflector and light were seen on the two days, as since that the weather has completely changed, so much so that yesterday it was with difficulty the places to mark the station by could be seen. Everything is now arranged and to-morrow [we] commence taking down the observatory tent and prepare for the staff and pile.

All those of us who have waited patiently on inhospitable hills, for the glimpse of a ray of light from a distant trigonometrical point, will sympathise with Colby, Murphy and Henderson on Divis ;

and still more with Drummond and Larcom on Slieve Snaght, for they were uncertain up to the last as to whether their labours had been successful. One says to oneself sometimes: "It's a dog's life—but it has great compensations."

In June, 1830, Colby writes: "Lt. Drummond is trying for a situation and is pretty well supported." The "situation" was in connection with the great Reform Bill; Drummond was, in 1831, appointed head of the Boundary Commission, which was necessary for laying down the new electoral areas. In 1833 he became Private Secretary to Lord Althorp, Chancellor of the Exchequer; and in 1835 he was appointed Under-Secretary for Ireland.

Neither the Lord-Lieutenant nor the Secretary, Lord Morpeth, took an active share in the administration of the country, and Drummond found himself the Governor of Ireland. There was, thus, a great change in the relative positions of Colby and Drummond; from being an officer on the Survey under Colby, Drummond became the ruler of the country which Colby was surveying; and it was, perhaps, inevitable that the situation should be a somewhat difficult one for Colby; though it must be remembered that the Survey was under the Ordnance and not under the Irish Government.

Some years later Colby writes to his wife: "I have doubts of Drummond having really committed himself by the observations attributed to him. He is incautious, but such observations are not like what he would have made on any subject when under me. However, I do not excuse him for not having written to me before he acted." And again on February 8th, 1840:—

"Lord Morpeth's letter was perfectly gentlemanlike and friendly to the Survey—but Drummond's was the most intemperate and offensive attack on the Survey you can possibly conceive. It fortunately happened that his zeal to injure the Survey carried him into a good many sheets of writing, and when there is great length and great bitterness, there is always room for a reply. I was, therefore, enabled clearly to establish his error quite to the satisfaction of the Master General on every essential point."

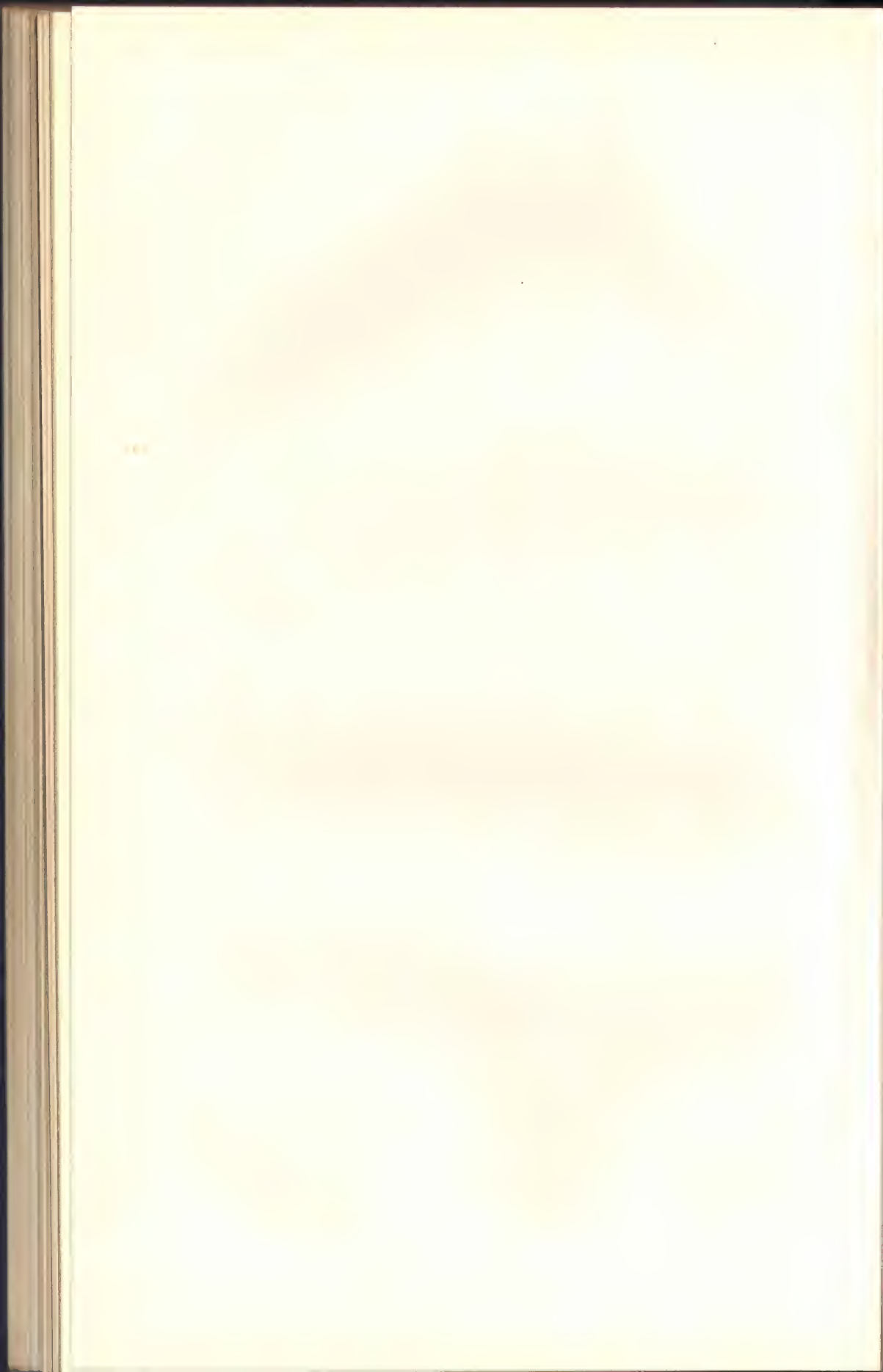
The particular cause of their dispute was the execution of the geological survey as an adjunct to the Ordnance survey—the former being included in the term "matters of mere curiosity" by a subordinate of the Board. But the Master-General stood by Colby; the Master-General, indeed, was not a little annoyed at receiving "a most impertinent letter from a Captain of your Corps, who because he is Secretary for Ireland takes upon himself to be insolent to the Ordnance."

It is to be regretted that the relations between Colby and Drummond were strained over this matter of the geology of Ireland, for Drummond had done good work for the Survey, and he died two months after the letter last quoted was written—worn out by overwork. He left the reputation of a real friend of the people



CAPTAIN THOMAS DRUMMOND, ROYAL ENGINEERS.
Under-Secretary to the Lord Lieutenant of Ireland.

Painted by H. W. Pickersgill, R.A., and engraved by Henry Cousins.



of Ireland; "moved by the miseries of the people, touched by the injuries to which they were being subjected, and pained by the evidence of misrule which everywhere met his eye."* It was he who told the Irish landlords that "property has its duties as well as its rights." O'Connell, convinced of his goodwill to the country, supported him.

Perhaps his chief administrative act was the foundation of that fine body the Royal Irish Constabulary, but no side of the administration was neglected by him. The continuous and overwhelming work, and the difficulties that he had to contend with, told rapidly on his health, and he died on the 15th April, 1840. It is not often that a man, who has distinguished himself in a technical sphere, becomes equally eminent in that of government; and Drummond, who had that double distinction, may properly be regarded as one of the most talented officers who have ever served in the Army.

Before giving an outline of Colby's career, it will be right to describe, very briefly, the lives of two officials of the Survey, who carried out much useful work under Mudge and Colby. Their names appear frequently in the accounts of the Trigonometrical Survey and in the technical correspondence of the period. These two officials are James Gardner and Robert Dawson.

James Gardner.—An important member of the Survey staff, during the whole of Mudge's directorate and later, was James Gardner, who, apparently, before the formal establishment of the department, was the "chief draughtsman" of the Board of Ordnance at the Tower. He was probably posted, as a Warrant Officer, to the Corps of Surveyors and Draughtsmen, in 1802. But it is not in connection with drawing that we usually find his name mentioned, but almost always with observing. It is recorded that he observed with the large theodolites at thirty-eight stations. The last stations he observed at being the cross-channel group, at which angles were re-observed in 1822, viz.: Crowborough, Fairlight, Folkestone, etc. He also assisted in the observations with Ramsden's zenith sector at Kellie Law, Cowhythe, Balta, and at Dunkirk across the water. And from the very commencement of the one-inch map he was constantly employed in fixing minor points for the "interior survey," as Mudge mentions in the accounts for 1791 to 1795.

We do not know much about him, except that he appears to have been a very efficient observer, who was connected with the survey for thirty years or so. But five letters from him to Colby have been preserved, and a few extracts from these may serve to give some information with regard to the personality of this old public servant.

* *Dictionary of National Biography.*

From Edinburgh, 31st May, 1816 :—

" I am glad to inform you that after watching night and day I have at length succeeded in catching the Dunrich hill, having got nine observations, seven of which agree remarkably well. To-day I expect to have the tenth Western elongation. . . I have not since you left seen further to the westward than the Orchills, and the only thing done in that quarter is taking the Camproys twice—Meridian marks are not so easily placed as I imagined."

He mentions the difficulty he had in getting permission to cut down a few trees that obstructed the rays :—

" A shrub in the neighbourhood of Falkland is as much thought of as the largest oak in Sherwood Forest."

" I have given the Woolwich party [of R.A.] money to buy shoes and shirts, and taken care that they have done so. At Woolwich they imagined perhaps that as the men were to get to Scotland, the nearer approximation to nudity they would the more easily pass for Scotchmen."

From Lincoln, 30th December, 1818 :—

" I have at length succeeded in getting points for Mr. Metcalf and Mr. Budgen. I am now at work in Mr. Stevens' district, and if the weather permits, shall have a stiffening of points for him by the end of next week, when I shall return to town unless I receive orders to the contrary. . . . I am sorry I did not take your advice and wait till spring. I never suffered so much fatigue and cold in my life. Glush Mull is a paradise compared to Lincolnshire at this season of the year ; we have been out several times till 10 and 11 o'clock at night, on account of thick fogs and bad roads, and when I return I shall be happy at the *novelty* of dry feet."

In another letter he sends his " best respects to Mr. Robe, Mr. Drummond and Mr. Dawson."

Wallingford, 18th November, 1821 :—

" I have just completed a week's work, but what with bad weather, short days, and roads almost impassable, the progress has not been such as I should have wished. Am sorry also to observe that I can derive but little advantage from Mr. Woolcott's work, not but that there is a good deal done, but the angles seem so roughly taken that it would be almost dangerous to incorporate them with anything that deserves the name of a trigonometrical survey, in some instances the great differences betwixt arcs arise from the clumsiness of the objects, many often clump objects at the distance of several miles have covered the field of view of my telescope!!! . . . The angles of Mr. Dawson's series seem to be very well taken ; I shall obtain a base to verify his series direct almost from the great instrument."

The last letter preserved deals with the printing of the maps of the Survey of Ireland. This letter is dated Regent Street, 7th February, 1827. Gardner had been appointed agent, *i.e.*, map-seller, to the Board of Ordnance. The reasons for the appointment are described by Colby, in a minute from which the following paragraphs are abstracted. The subject of map sales is dull enough, but it affects the finance of the Survey and is one which continually

recurs in its history. The matter was not satisfactorily settled until a few years ago.

Colby writes :—

“ When I had the honour of receiving from the Duke of Wellington the appointment of Superintendent of the Survey in 1820, I found the sale of the maps carried on in two ways, the one by the principal engraver at the Office in the Tower, the other by Mr. Faden, the mapseller, at Charing Cross. A trade price and a selling price were established, but all those who came to the Tower received maps at the trade price, whilst those who purchased of Mr. Faden paid the selling price. The sale of the maps at the trade price to the public at the Tower irritated all the mapsellers against the Ordnance . . . and they most strenuously opposed the sale of the maps by every means in their power. . . . On the 30th August, 1820, the Master General and Board were pleased to grant Mr. Faden an allowance of 10 per cent. to enable him to supply the rest of the trade. . . . He received maps from the Tower on sale or return. . . . Mr. Faden was not bound by any agreement to sell the Ordnance maps in preference to others.”

This arrangement did not work well, largely because the discount allowed was too low.

“ When Mr. Faden retired from business the Honourable Board entered into an agreement with Mr. James Gardner, who was well qualified as a geographer, to act as their agent. And he on the faith of his agreement purchased a house in Regent Street to carry on the sale of their maps, and bound himself down not to sell any other maps which would supersede them.”

That is almost all that we know about James Gardner ; but, perhaps, even less will be known about most of us a hundred years hence.

Robert Dawson.—The Survey was such a small department, in those days of the early nineteenth century, that the personality of each member of it counted for a good deal ; and, happily, there were no failures amongst the five who, until 1916, were chiefly responsible, namely, Mudge, Colby, Woolcot, Gardner and Dawson. Robert Dawson was born in 1776 and, when he was eighteen, he was employed as a draughtsman under the Board of Ordnance, at a salary of £54 a year. The Corps of Royal Military Surveyors and Draughtsmen was formed in 1802, and consisted of warrant officers, selected for their skill in carrying out the “ interior ” survey. Amongst those appointed, on the formation of the corps, was Dawson. It appears that he had already been selected to instruct, in drawing and surveying, the officers intended for that branch of the Q.M.G.’s department which eventually became the Intelligence Division.

“ To General Morse . . . was due the very judicious idea of rendering this corps useful in instructing the young Engineer officers in sketching and surveying. . . . At his request, General Mudge allowed Mr. Stanley

and Mr. Dawson, two of the most able surveyors and draughtsmen of the corps, to undertake this task.”*

The young officers were attached to the Survey and were sent to the field wherever Dawson happened to be working. When Addiscombe was established, in 1810, Mudge entrusted the field instruction of the cadets, in surveying and drawing, to Dawson. So that probably Dawson, more than any other man of his time, formed the ideas of the Army in this branch of military art.

It is said that :—

“ Besides his other qualifications, Mr. Dawson had the merit of bringing topographical drawing to a degree of perfection that had given to his plans a beauty and accuracy of expression which some of our eminent artists had previously supposed unattainable.”†

Portlock speaks of Dawson's great artistic talents. Some of Dawson's topographical drawings of the Welsh mountains are said to have been the finest ever produced. Two sheets of Dawson's hill drawings on the 2-inch scale (Snowdon and Cader Idris) are preserved at the Ordnance Survey Office, Southampton. Whilst it may be said that they do not, perhaps, deserve the unstinted praise given to them by contemporaries, they are, nevertheless, excellent examples of the art, and admirable guides for the engravers.‡

He died at Woodleigh Rectory, Devon, in 1860, aged eighty-four.

Some letters written by Dawson to Colby show that they were on very friendly terms. On the 6th February, 1812, he writes from Worcester :—

“ I see you are within one step of a 1st Captain and hope to live to see you many steps above it, and as much my friend as ever, though the progress of rank may increase our distance.”

In another letter he writes that Mudge has permitted him “ to take his East India pupils and engage in a reconnoitring and sketching essay for their instruction, with the usual travelling allowance from the Company,” into the mountains of North Wales. The party travelled sometimes on horseback, sometimes on foot, and sometimes by chaise. They surveyed with the compass (he writes in one of his letters about testing the variation of the compass), made “ panorama views ” and perspective sketches. He says that he has been so pressed to project his work that he had not even written to Colonel Mudge. In an undated letter he writes of “ the gratification you must have felt in visiting the Quarter Master-General's office. The stone printing interests me much, and I should

* Portlock's *Memoir of Major-General Colby*.

† *Memoir of the Mudge Family*, p. 140.

‡ The portion of Dawson's drawing of the Snowdon district, here reproduced, hardly does justice to his skill, owing to the bad state of the paper. The date should be “ about 1820,” and not 1815, as printed.

HILL DRAWING OF PART OF THE SNOWDON AREA.

By Robert Dawson, of the Ordnance Survey 1776-1860.

Drawn in the year 1815.



like to try it of all things, for if it can be done with good definition and effect it must be an admirable contrivance."

In April, 1814, he writes from Shiffnal :—

" Perhaps you have seen the letter I sent yesterday with the Reports of the Candidates' Progress to Colonel Mudge. I fear that he will think it too severe. I wrote quick and meant to be just, and I believe was so, but I was certainly a good deal chafed with the friction I encounter in some of the young men—and besides a little bilious, and perhaps not a little splenetic from its effects. However, it is necessary that Colonel Mudge should know that these young men want some check from his hand. . . Mr. Blackiston is a very well bottomed young man, rather heavy, and his faculties not yet pointed. . . Would it be too much to ask, through Colonel Mudge, for a copy of Major Lambton's account of his trigonometrical survey in India. . . I think it might be useful to have it to shew to the E. India Cadets."

On the 8th December, 1815, from Lichfield :—

" . . . May I not aim at a large and striking example of topography in my new Welsh work—and may not the Cader Idris plan be a sort of coup d'essai on the effect to be produced ? "

On the 14th of the same month :—

" Perhaps it will be best to have all the plans of the survey done in Indian ink for the future, and as near the effect of engraving as may be. . . Mrs. D. and myself were wishing last night that we could have the quiet leisurely comfort of your company once more, before a deluge of pupils comes upon us."

On the 8th January, 1816 :

" I have given a good deal of time to Cader Idris, which now is getting into something like its finished effect. . . It must necessarily be a long time before there are many competent judges of these particulars. . . The Geological Society has a direct tendency to increase intelligence and interests in the thing, and by its means it probably will be brought to a high pitch of improvement."

In 1824 he describes some of the officers whom he is instructing :—

" Mr. Durnford has hardly been long enough with me yet for his character to come out. I think he has good capabilities and does everything in a solid and accurate manner."

In the same year he complains that the Master-General will not give him a permanent position. Later on this was rectified. He found it hard work to get out of the Honourable Board the money due for surveying and correcting sheets ; the Board appears to have been always behindhand in payments :

" Allow me to beg you to not let the money be delayed for my surveying. I want it much, and shall be extremely obliged for your interference to hasten its payment." " I am very sorry to learn you have met with delay and objection in regard to the Contingent Bill," etc.

He kept up a correspondence with his Indian pupils :—

" W. N. Forbes . . poor fellow, had been extremely ill from the climate, but had struggled on, and got nearly thro' a very extensive survey of

part of the Delta of the Ganges. Of Macleod we have twice heard lately and of his excursions on the Ghauts and with Sir John Hislop's Army. Oliphant has written me an account of his journey with the Madras Army," and so on.

Certainly Robert Dawson was an important member of the limited staff of the old Survey, and his letters give a very pleasant idea of his character.

Robert K. Dawson—his eldest son—was educated at the R.M.A., Woolwich, under Mudge. He was commissioned in the Royal Engineers in 1818, and was employed under Colby on the Ordnance Survey. He retired as a Lt.-Colonel and became head of the Survey Department of the Commons Enclosure and Copyhold Commission. He died in 1861, less than a year after his father. A few of his letters to Colby remain, mostly on technical subjects. In March, 1822 :—

"The churchwardens at Frant are a little annoyed at having your Gothic Pole on their modern edifice and wish it removed from their new church as soon as possible."

In the same month :—

"The sketching of Budgeon's work (in the neighbourhood of Sleaford particularly) is decidedly bad."

From Mull, 13th September, 1822 :—

"The observatory was taken down on Tuesday last and embarked at the small isles, where we were detained till Friday morning by a tremendous gale of wind, which if we had awaited it on the hill would certainly have sent us down without horses. We arrived here last night, and as the weather now appears to promise well we are compelled to make this a working day. . . Captain Melville [R.N.] is as usual rendering us great service."

On the 30th of the same month :—

" . . . Allow me, my dear sir, to offer you now my sincere thanks for your kind attention and consideration to my father—and particularly for your regulation, which secures to him the advantage of an assistant, for his health is now declining so fast." N.B.—The old gentleman lived for 38 years more.

In another letter he says :—

"Most happy shall I be to leave this gloomy hill [Jura]. As yet we have only on one occasion ventured more than a mile from this camp, and then the hill was covered from morning till night."

After the commencement of the Survey of Ireland, he writes from the Tower on 10th October, 1825 :—

"By the Liverpool Canal on Saturday we forwarded to Major Reid at Dublin six cases of instruments. . . The characteristics [*i.e.*, conventional signs] shall be sent in a Frank to-morrow."

VII.—THOMAS COLBY.

Thomas Colby.—Mudge was fortunate in his successor. It is difficult to imagine that any officer can have been more entirely fitted to direct the survey of this country than Thomas Colby. He had joined the department as a young subaltern in January, 1802; he became Mudge's right-hand man and took a large share in the general conduct of the operations during Mudge's life-time; and on Mudge's death, in 1820, he was appointed by the Duke of Wellington to succeed him: but not until the Duke had thoroughly satisfied himself that Colby was the right man.

Mudge died on the 17th April, 1820, but Colby was not appointed until the 10th July, by a letter from the Office of Ordnance of that date, signed by Lord Fitz-Roy Somerset:—

“ I am directed by the Master-General to acquaint you that His Grace appoints you to succeed the late M.-General Mudge in the superintendence of the Ordnance Trigonometrical Survey; and the requisite notifications have been made accordingly.”

During the three months' delay, Colby, not unnaturally, became a little restive, and wrote to His Grace on the 20th June a somewhat lengthy letter, in which the following passages occur:—

“ I have used no interest, I have solicited no one of your Grace's noble friends to paint my character or conduct on the Survey in glowing colors; but I have had a firm but humble reliance that your Grace would, when the press of more important business allowed opportunity, enquire how far my conduct and character would render me deserving of confidence and enable me to conduct the Survey with efficiency and credit to the country.”

He then mentions, as men qualified to give an opinion on his work, “ Dr. Charles Hutton, of Bedford Row, the late very eminent Professor of Mathematics at the Royal Military Academy; Professor Bonnycastle and Dr. Gregory, of the Woolwich Academy; Dr. William Pearson, of East Sheen; the Professors of Natural Philosophy and Mathematics at Edinburgh, Aberdeen and St. Andrews.”

This letter produced an immediate answer, which, judging from its style, was perhaps dictated by the Duke himself:—

Office of Ordnance,
21st June, 1820.

“ SIR,

“ I am directed by the Master General to acknowledge the receipt of your letter of the 20th instant, and to acquaint you that His Grace is

now making enquiries, and will let you know whether he will appoint you permanently to conduct the Survey or not. In the meantime, the Master General begs you will continue it, in like manner as General Mudge would have done.

" His Grace at the same time desires me to inform you that he entirely approves of your not having urged any of your Friends to apply to Him ; and that you may rely upon it that neither upon this, nor upon any other occasion, could a private application be made to the Duke, without diminishing the favourable opinion which His Grace might entertain of the person in whose behalf it should be made.

" I am, etc.,

FITZ ROY SOMERSET."

His Grace proceeded to consult various scientific men as to Colby's fitness to take charge of the Survey, and amongst others he wrote to Sir Humphrey Davy, who replied that not only was Colby the officer best fitted for the appointment, but that it was in a sense his right, as he had been so long in charge of the greater part of the work. The Duke also sent for Dr. Hutton, and the story of the interview is told in several ways. The doctor, on entering the room, was at once asked by His Grace if Colby was the best man to take charge, and began a speech, " No man more so, My Lord Duke . . ." when the Duke cut him short with, " Thank you, Dr. Hutton, that is all I want to know ; my time is valuable, and yours, I know, is not less so." And so Colby was appointed.

He was then a captain, and the Board of Ordnance paid him, on appointment, £1 7s. 8½d. a day, or about £500 a year.

He remained Director of the Survey until his retirement from the Army in 1846. He was, thus, continuously employed in the Department for 44 years, and during 26 of these he was in control of it. Like Mudge, he was devoted to his subject. Like him, also, he had many official difficulties to contend with, and had to put up with the same indignity of an official enquiry into his work. But, before he retired, he had the satisfaction of seeing the Ordnance Survey firmly established in public and official estimation, and he had succeeded in greatly expanding the scope of its activities and in increasing its usefulness to the country.

According to Portlock, whose *Memoir of Major-General Colby* is the principal source of information with regard to Colby's early life,

" The grandfather of General Colby was Mr. Colby, of Rhosy Gilwin, Newcastle Emylin, South Wales, a gentleman of considerable landed property. His father, Thomas Colby, was an only son, and an officer of Royal Marines. For many years he appears to have been attached to the Chatham Division of Marines, and at that station most, if not all, of his children were born, the births of four being recorded in the registry of St. Margaret's *next* Rochester."

Captain Colby was severely wounded "at the glorious battle of the 1st of June," 1794.

Colby's mother was Cordelia, sister to General Hadden, R.A., a distinguished soldier. Thomas Frederick Colby, the future Director of the Survey, was born on the 1st September, 1784, at Rochester, and his early years were passed either at Rochester or Chatham; but, when his father again went to sea, he was put under the care of his father's sisters at the family seat, Rhosy Gilwin, and by them brought up until sent to school at Northfleet in Kent. From Northfleet he went to the R.M. Academy, Woolwich, and was commissioned as second-lieutenant of Engineers on the 21st December, 1801.

In the following January he was posted to the Survey under Mudge, whose letter to the Master-General reads:—"I find him, on examination, well grounded in the rudiments of mathematics, and in other respects perfectly calculated to be employed in this business. I beg to point out to your lordship the expediency of Lieutenant Colby being attached to me with some degree of permanency, and to request you will assign him to my orders on that principle." He was posted to the Survey on the 12th January. There cannot be any doubt that General Hadden, then Surveyor-General of the Ordnance, was the prime mover in his nephew's appointment, but it is equally certain that Mudge was satisfied that young Colby was fitted for the work. In after years he had every reason to be pleased that the Surveyor-General's nephew had been chosen. As to the "degree of permanency," we have seen that Colby remained "in this business" for 44 years.

Although Colby was christened *Thomas Frederick*, he never seems to have used the second name, but always signed himself T. Colby or Thomas Colby.

In 1803 Colby suffered an accident which materially affected him for the rest of his life. He was engaged on a tour of inspection, and was examining Mr. Dawson's work on the interior survey of Cornwall, and that of his first batch of pupils, when the accident occurred.

Mudge thus describes it in a letter to General Morse, dated Liskeard, December 16th, 1803:—

"I am extremely sorry to announce, for your information, a most unfortunate occurrence. On Monday last Lieut. Colby, in the act of placing an overloaded pistol on the ground, was severely wounded from its going off unexpectedly: his left hand grasped the barrel and was so violently injured that amputation became necessary: it accordingly was taken off just above the wrist the same evening. The loss of his hand is not the only misfortune to be deplored, as his skull received a violent blow, producing a fracture in the forehead. . . . The brain, it seems, remains free from any injury; nor is any future evil apprehended, beyond a scar.

‘ Mr. Dawson, with whom Lt. Colby was living, and to whose house he was brought, took every proper step, and amongst others immediately sent to me. I consequently came with all possible speed. It is . . . with a degree of satisfaction proportionate to my regard for this most excellent but unfortunate young man that I have to state the confident expectations entertained of his recovery, without the smallest injury to his intellects.’

Colby was a man of unusual strength of constitution, and he recovered ; but for the rest of his life his forehead bore the mark of the accident. He accustomed himself to observe with the large instruments, though he had only his right hand. Portlock, who knew him well, wrote in the *Memoir* that it was “ impossible not to recognise in the injury inflicted on his skull a sufficient cause both for subsequent bodily ailments and for a reluctance to enter on long continued mental exertion.” However that may be, there is abundant evidence that the injury did not, in later years, materially affect his activity either of mind or body, though we may, perhaps, attribute to it a certain unwillingness to tire himself with controversy.

It has been seen how much personal work Colby carried out during Mudge’s directorate. The following letter from Colby to Mudge describes some of the conditions of work in Scotland :—

Bencloch, near Alton,

24th July, 1818.

“ The country which we have now to deal with is so extremely wild and destitute of accommodations of every kind, and the mountains are so high and difficult of access, and, moreover, seem at such long distances, that they require larger objects than those that were wont formerly to be erected, in consequence I have been compelled to send two men together instead of one alone to erect the objects, and the allowance of 2s. 6d. each object heretofore granted is become obviously too small. I have, therefore, to request that you will sanction me in raising it to 3s. 6d. each object. . . In this, as in everything else which regards the Survey, I have paid the utmost attention to economy, and I am willing to try the effect of what I consider as a minimum allowance. . . In the western part of Scotland, from the want of roads and carts, and the extreme height of the mountains, no station can be visited without very considerable expense, and I shall, therefore, endeavour to perform the Survey of it with as few stations as possible by the intersections of objects on the mountains, which will serve all the requisites of the map. . . ”

Portlock includes in his *Memoir* an account, written in 1852, by Major R. K. Dawson, of a season spent under Colby’s command in the Highlands. This account, from which the following paragraphs are extracted, gives an excellent picture of Colby’s manner of life when at work, before he became Director of the Survey :—

“ In the month of May, 1819, Lieutenant Robe and myself were appointed assistants to Capt. Colby on the Trigonometrical Survey,

and on the 5th June following I embarked in charge of a selected party of artillerymen, the instruments, and camp-equipment, for Aberdeen. . .

" We were joined at Huntley by Captain Colby, he having travelled through from London on the mail coach. . . . This was Captain Colby's usual mode of travelling, neither rain nor snow, nor any degree of severity in the weather, would induce him to take an inside seat or to tie a shawl round his throat ; but, muffled in a thick box-coat, and with his servant Frazer, an old artilleryman, by his side, he would pursue his journey for days and nights together, with but little refreshment, and that of the plainest kind—commonly only meat and bread, with tea or a glass of beer.

From Huntley, Captain Colby proceeded with us on foot, and on the second afternoon we reached the base of the mountain [Corrie Habbie] in Glen-Fiddick, near to a hunting lodge of the Duke of Gordon. Here, by partially reducing the loads on the cars, and by the application of guy-ropes to support them, and with the men's shoulders to the wheels, we climbed up as far as we could ; and, having unloaded the cars, made an irregular kind of encampment for the night. It was a fine evening ; and we had need, therefore, of but slight covering ; and anything like luxury was, of course, out of the question. A marquee was pitched for Captain Colby, in which he slept, in his clothes, on a bundle of tent-linings ; and I, knowing no better, was content to put up with the like accommodation ; but Robe, who had recently been with the Army of Occupation in France, like an experienced campaigner, set to work with his Portuguese servant, Antonio, who had also been with him on the continent, and soon put up his camp bedstead, and made himself much more comfortable—a lesson which I did not fail to profit by in my after-experience.

" On the following morning the really laborious part of the business commenced, that of conveying the camp-equipment, instruments, and stores to the top of the mountain. Horses were hired for the purpose and made to carry the packages slung like panniers over their backs, so far as the ground proved tolerably even and firm ; but when it became broken and hummocky, which is commonly the case with peaty soils, or springy and wet, there was then no alternative but to unload the horses and carry the things on the men's shoulders. . . Captain Colby went on, taking Robe and myself with him, to the summit, where he selected a spot of ground for the encampment as near as practicable to the station, and also for the watch-tent, at a point much nearer still. He then selected a suitable place for a turf-hovel, to be built on the sloping face of the hill, with a tarpaulin roof, in which to make a fire for cooking, and for drying the men's shoes and clothes, and to serve also as a place of shelter and warmth for the men in tempestuous and severe weather. When some of the tents had been brought up, and one or two of them pitched for present use, a party of the men were withdrawn from this duty, and employed in pulling down the conical pile of stones built round the station-staff, and in setting up in its place the observatory-tent. The requisite steps were then taken for securing the table or stand, for the great theodolite ; and the theodolite itself was then brought up with special care and fixed in its position. . . .

" When the arrangements in the observatory had been completed, and the summit of the hill was free from clouds, every moment favourable for observation was anxiously caught by Captain Colby, and devoted to that service, from sunrise to sunset. At other times he imparted to Robe and myself a knowledge of Ramsden's great three-foot theodolite, and of its adjustments, as also of the mode of working and entering the computations. . .

" 29th of June.—Captain Colby took Robe and a small party of the men on a ' station hunt,' or pedestrian excursion, to explore the country, along the eastern coast of Invernesshire, Rosshire, and Caithness, and to erect objects upon some of the principal mountains, and select those which from their position and circumstances should be preferred for future encampments. . .

" 21st of July.—Captain Colby and Robe returned to camp, having explored all the country along the eastern side of the counties of Inverness, Ross, and Caithness, as well as the mainland of Orkney, and having walked 513 miles in twenty-two days.

" 23rd of July.—Captain Colby took me and a fresh party of soldiers on a station-hunt, to explore the country to the westward and northward of west."

The first day they walked 39 miles, having " crossed several beautiful glens " and avoided the beaten track as much as possible. In the middle of the second day Dawson thought that he really could not stand any more of it, and " petitioned strongly " to be excused from accompanying Colby. But the latter would not listen to his subaltern's petition and Dawson had to limp along. But he soon got broken in, and in a day or two was able to walk with the best of them. They got back to the top of Corrie Habbie on the 14th August, having walked 586 miles in twenty-two days.

Dawson (junior) says that on Sunday, 1st August, 1819,

" I so far forgot the sacred nature of the day as to commence whistling some light air. Captain Colby very properly checked me in so doing, explaining to me the deep sense of veneration with which the people of that country regard the Sabbath, and the next day I was informed, while on the march, by one of our men, that he had been urged by the landlord to come to me and beg me to cease whistling, dreading that some judgment should otherwise fall upon his house."

The Duke of Gordon helped in every possible way whilst the party was in the neighbourhood of Glen Fiddick, and came up the hill frequently to see Colby. He took no small interest in the work and carried out some of the barometer observations himself. The observations with the great theodolite were finished on the 28th September. After the instruments had been safely packed, Colby gave the men *carte blanche* to provide themselves a farewell feast.

" The chief dish on such occasions was an enormous plum-pudding, the approved proportions of the ingredients being—a pound of raisins, a pound of currants, a pound of suet, etc., to each pound of flour ; these quantities were all multiplied by the number of mouths in camp, and the

result was a pudding of nearly a hundred pounds weight." This gigantic pudding was suspended by a cord from a cross-beam and boiled for twenty-four hours in a brewing-copper. "A long table was spread in three of the marquees, pitched close side by side and looped up for the purpose, and seats being placed also for Colby and his subs., we partook of the pudding, which was excellent, and withdrew, after drinking '*Success to the Trig.*'"

R. K. Dawson says that, after Colby was appointed Director, he was out with Vetch, Drummond and himself, in 1821, in the Orkneys and Shetlands, and in the solitary islands of Faira and Foula. In 1822 Colby was with Vetch and Dawson exploring the whole range of the western islands of Scotland. In 1825, the scene having shifted to Ireland, he camped on Divis, and in 1826 on Slieve Donard; and was not again in camp for any length of time until the resumption of the Survey of Scotland in 1838.

As the result of the report of a Select Committee of the House of Commons, the Survey of Ireland on the scale of six inches to one mile was commenced, under Colby's direction, in 1825. But the Tower of London still remained the Survey headquarters, although all but one of the officers were transferred to Ireland; Richard Mudge only, with a few engravers (and perhaps one or two of the surveyors engaged on the English detail work) remaining at the Tower. Colby himself led a migratory existence, being sometimes in Ireland and sometimes in London. The triangulation of Scotland was stopped, and no further work was done on it until 1838.

The last winter that all the officers were present at the Tower was that of 1824-25. Portlock says that Colby's "ardent zeal and craving for improvement spread quickly amongst the young officers serving under him, and setting them also thinking and working," rendered the winter memorable in the annals of the Survey. The officers were:—Richard Mudge, Robe, Drummond, Murphy, Dawson, Larcom and Portlock. Drummond's quarters in Furnival's Inn "became a laboratory and workshop." Everyone who knew Colby in those days "must remember how rapidly he moved or ran through the streets, rarely relapsing into a simple walk; and it was thus that I met him rapidly descending Tower Hill, when he took my arm, and with the usual, "Come, my boy, I have something to talk to you about," carried me back with him to the map office in the Tower, which was not only the office for the business of the Survey, including the engraving of the maps, but also contained the private apartments allotted to Major Colby as director of the work."* Portlock had dinner there with Colby, who explained to him his idea of compensation bars for base measurement, it being certain that a base would shortly have to be measured in Ireland.

* Portlock's *Memoir of General Colby*.

In 1828 Colby married Elizabeth, the second daughter of Archibald Boyd, of Londonderry, and took a house in Mountjoy Square, Dublin. In 1830 he rented Knockmaroon Lodge, close to one of the gates of Phoenix Park, and a few minutes' walk from Mountjoy House, which had become the headquarters of the Survey of Ireland. He had four sons and three daughters. Two of the daughters, Anne and Cordelia, survived until within a few months of the writing of this paragraph; they died at Clifton in the autumn of 1924, within a few weeks of each other, having lived to a great age, and to the last were keenly interested in the memories of their father's life. They entrusted to the present writer a great number of letters and documents which had been collected by their father.

In the collection above mentioned is a bundle of (copies of) letters written by Colby to his wife, between 1830 and 1844, covering a great part of the period of Colby's administration of the Survey of Ireland. In a letter written on the 8th May, 1830, from Liverpool to Knockmaroon Lodge, Colby says:—

"We went in a fly to the railroad and walked about a mile, where stupendous excavations through rock are in progress. We then got upon the steam carriage and went a mile with a dozen wagons fastened to our rear. The perfect ease with which these carriages can be managed is really beautiful—not like the pulling and hauling with horses. We could run up to a thing, and push it along in the most gentle manner without the slightest concussion, and stop or go backwards or forwards with equal ease. As the steam had got low and no experiments were in progress, we only went at the rate of 16 miles an hour."

On the 28th May:—

"On my arrival [in London] I found things in somewhat of a new train and that my influence in society was not in the least improved by my having been bottled up in Ireland for the greater part of a year. The Civil Engineers Club has almost ceased to exist. The Astronomical Society have got a little bad feeling among them. The Royal Society have a similar evil to contend with. The Athenæum are not in the most thriving possible state, and the Geological alone remains uninjured by folly or party feeling. . . . A new Geographical Society is started and I am one of the provisional committee for its management. It bids fair to do well. Lord Aberdeen and all the leading people in his department, Lord Melville and the principal Naval characters, and, indeed, most of the Ministers, are in it. . . . I have paid £5 to the Charter fund of the Astronomical Society; £3 12s. to the Geological Club, and £2 8s. to the Royal Society Club; £1 for silk stockings and 16s. 6d. for shoes—you see I am not extravagant."

June 3rd, 1830, Tower to Knockmaroon:—

" . . . I dine with Lord Hill, the Commander of the Forces, on the Saturday after next, and I have a Member of the House of Commons on the look-out to assist me in getting at those I want to aid in carrying my public objects in relation to the Irish Survey. I mean to be a little

more independent of the good or bad will of the Master General when I return; at least things are getting into train. The Member I allude to is not in office, but he is a personal friend of the Duke of W., Lord F. Somerset, Sir H. Hardinge, and of Peel and the other leaders of the Ministerial party. I am also at work through another channel to secure the support of Lord Lansdowne and that party. I am not asking personal favours, and therefore no interested motive can appear to operate against me. I have also taken further steps to secure the Survey against any unpleasant observations from Mr. Hume and his party; and I have also a promise of a committee next session for the Survey if I want support. You see, I have been on the look-out here."

23rd June, 1830:—

" . . . I have been working away for Ireland at a great rate, to get the bogs drained, etc., but the difficulties are enormous. I was yesterday first with Lord Downes (who, by the way, is turned civil and asked me to lunch at his house) and Colonel Rochfort about it. Next I went to the Irish Office to push the matter with Sir Charles Flint and the Irish Government, then to Sir Thomas Towlins, who is drawing the Bill for the drainage, and then to the House to get Brownlow and Sir H. Parnell rather to let the Bill pass with clauses which may impede its working than to throw it out altogether. It is uphill work and I would rather be at home, but I believe that I have saved the Bill from being thrown out. . . "

December 2nd, 1831, London to Knockmaroon:—

" . . . You would have been amused if you had heard the *odd* speeches at the Royal Society Dinner. The Duke of Sussex evinced much good humour. When he gave the Queen's health, he told us that 'she contributed to the King's comfort,' and he called the Royal Society the 'Mamma' of the new societies, and he designated himself the Husband of the old Mamma.' He told us it was difficult to find men who would tell princes the truth, and that he could only get at it now and then by stealth. He drank wine with a few individually at dinner, and with the remainder in parties of six or seven. There were few great men there, and I was included among those who received the individual compliment. . . "

February 14th, 1832:—

" . . . Our new clerk, Mr. Kennedy, seems a sensible, straightforward, intelligent man. He is to be with me at the Tower on Thursday."

February 28th, 1832:—

" . . . When I am no more, I trust those I leave will not think it necessary to pay any pompous respect to the worthless remnant of what once was me. The tribute of sincere affection is all I desire, and the cheerful belief that my conduct below has not rendered my removal a matter to be regretted on my own account. But while I am here, it is my duty to do the best I can for those I love. I, therefore, take as much care as I can to prolong my existence."

December 4th, 1832, Tower to Knockmaroon:—

" . . . I dine to-day with Sir James South and on Thursday with

the Master General. But my official duty is very uphill work, though we are all personally on the most friendly terms."

May 9th, 1833 :—

"I have had a long private audience with the King to-day. He was very gracious, and looked over the whole atlas of Derry very carefully, sheet by sheet, asking questions about them and the Survey, and expressing his approbation, not only of the maps, but also of his Corps of Engineers and Artillery and of the Ordnance Department under which the work was executed. When Sir James Kempt introduced me, the King said, 'he ought to have been ashamed of himself for not immediately remembering Colonel Colby'—that he thought I had belonged to the Artillery, and did not recognise me in the Engineers' uniform.

"It is gratifying that the first Irish map has been so well received."

In January, 1834, Colby suggested to the authorities that Captain Richard Mudge should carry on the English Survey independently, in order that he, Colby, might devote his whole attention to the completion of the Irish work. This is a proof that the English survey was still being slowly proceeded with, although the survey of Scotland had been stopped. It appears that the authorities still left Colby in general charge of the English work. "I had made up my mind to the sacrifice of my salary for the sake of advancing the Irish work." In later years he did undoubtedly sacrifice a large part of his salary for the same object, but it does not appear that this happened in 1834.

In September, 1835, he says that he has been down to Woolwich with Sir H. Vivian to see "the new Pontoon Bridge of Major Blanchard's invention. . . I returned with Sir H. to London . . . went straight to the Tower, did my business, and dined with Robe close to the Tower."

May 29th, 1837 :—

"Babbage has published a new book on Natural Theology, and his parties are crowded to excess. He gives one every Saturday, and as I came home past his door last Saturday, I am sure there were more than a hundred carriages waiting."

May 26th, 1837 :—

" . . . My having been in London is most fortunate, for poor Dawson's complete failure in the tithe commutation business would have cast a sad damp upon all our work if I had not been here to avert the evil. The Scotch are coming forward for their Survey in good earnest. The Societies have petitioned, and some influential men see the Chancellor of the Exchequer to-morrow about it. A more powerful mass of noblemen and gentlemen are coming forward on that point, and it is quite necessary that I should be here to guide and prevent such blunders as have happened in the tithe commutation business. There is nobody that I could trust to put in charge of the Scotch Survey, and I suppose I must make it part of my business. All the leading movers of the matter are my personal friends."

May 7th, 1838 :—

" . . . Left the Tower about $\frac{1}{2}$ past 3 o'clock, and went to the Engineers' Office. All gone but Colonel Wells. Went into the Ordnance Office, had a long conversation with the Master General ; asked to dinner on Sunday. Went to the Club. Murchison kept me a good while talking about geology."

May 19th, 1838 :—

" . . . I breakfasted to-day with a party at Mr. Baily's, lilies, tulips, etc., in the middle of the table—broiled salmon, roast pigeons, cold fowl, ham, plovers' eggs, prawns, and a party of philosophers : Sir John Herschel, who has just returned from the Cape of Good Hope, the Editor of the Nautical Almanac, Captain Smyth, the Professor of Natural Philosophy from Edinburgh, two Cambridge professors, Baily and I. Sir John enquired after you. . ."

June 5th, 1838 :—

" . . . Jervis and Lock, the Director of the E.I. Company, took my time yesterday at the Tower."

June 6th, 1838 :—

" . . . I dine at Mr. Baily's to meet some of the foreign astronomers. These dinners are sad hindrances. We had a very good dinner at the Greenwich Observatory Visitation on Saturday and a very pleasant party of about 16—Mr. Baily in the chair—the astronomers of Greenwich, Cambridge and Edinburgh, Oxford, etc. Healths drunk, speeches, etc. Colonel Pasley has succeeded in blowing up two wrecks, and he is quite happy."

July 9th, 1838 :—

" . . . On Saturday the Duke of Wellington came to the Tower to present the new colours to the 20th Regiment, and after the presentation he did me the favour to call at the office, with Lord Hill, Lord Fitz-Roy Somerset and several other general officers, and I had the honour of shaking hands once more with my old and much esteemed Commander."

Writing from Perth, where he had gone to make arrangements for the resumption of the Survey of Scotland, Colby says :—

" Sir Charles Gordon told me that if I wished to have introductions to any of the proprietors, that the members of the Highland Society would be happy to give them to me, and they have put a paragraph in their report, expressing their wish that every assistance shall be given to the persons employed on the Survey throughout Scotland."

December 5th, 1838 :—

" . . . Jervis is working away to get my system introduced in the Indian Survey ; but as yet he is violently opposed by all the East India underlings."

May 8th, 1840 :—

" . . . I had a very long conversation with Sir Hussey yesterday morning about the proposed survey of Scotland. . . I have had heavy work to face all opposition, but the Engineer Office are now very civil to me—and everything is apparently smooth. The Inspector General has recommended the instruction of the young officers of Corps, and

non-commissioned officers on the Survey. This is complimentary, but what will Pasley say to it? . . . We are friends now, and both Ellicombe and Fanshawe are on my side. When I was buried in Ireland I had no opportunity for meeting difficulties."

In 1842 the headquarter offices of the Survey were established in Southampton, and Colby's letters from this date are mostly written from that town or from London. On October 31st, 1842, he says that he has seen Lord FitzRoy Somerset and Sir Henry Hardinge about the new scale of the English survey. On November 4th he writes that he left Southampton at 11 and got to London at 2.

On the 5th November :—

"The Engineer Office and the Ordnance Office were very civil to me to-day—perhaps they think it as well to be so as the Master General does not agree with them against me."

November 10th, 1842 :—

"Not many years since the value of a knowledge of Latin and Greek with a good flow of language for public speaking were so great that a man possessing them was allowed a high station in society, and supposed fit to govern others; though he might have been profoundly ignorant of everything but *words*. These times are changing. Men who learn to think aright, and to know what is going on both in the natural and moral world are rising in importance. The conceit which is engendered by ornamental or unsubstantial knowledge is giving way."

November 17th, 1842 :—

"My base apparatus has returned from the Cape of Good Hope, and I am in daily expectation of its coming here."

November 28th :—

"Yesterday was a fine morning and I walked to Romsey, where I heard a good sermon in the church there."

December 4th :—

"I am still in the dark as to what is to be done with the Survey, though I have just had a long conversation with Sir George Murray, the Master General, who is well disposed to me about it."

From an undated letter :—

"The little strip inside are penny postage stamps; by wetting one of these and sticking on the back of a letter not weighing more than half an ounce, you save sending a penny to the post office."

February 11th, 1843 :—

"I stand alone, with all the Surveyors in the kingdom against me—with the desire of the Inspector General's office (under whom I act) to take every opportunity of opposing me—with the Board of Ordnance mostly against me—the Master General neuter, and the Treasury desirous of putting the money spent under my direction under some one who will be less honestly inclined to prevent their exercise of patronage in appointments; and, my only chance of standing alone against this opposition, is that everything done under my direction shall be quite unimpeachable in every respect, for I have neither money to bribe

by good dinners, or health or leisure for political intrigues. . . During the last 12 months I have refused 65 applications for employment—many of them recommendations by noblemen, and influential members of the House of Commons ; and several by the Master General and Members of the Board of Ordnance.” . . .

November 12th, 1843 :—

“ My department is so powerful that I can (if they will allow money enough) carry on the American boundary, the Hong Kong Survey, the London Survey and the Scotch Survey, without checking the English or Irish Surveys.”

December 12th :—

“ Yesterday evening I went to the Geographical Society, where they had more of Dr. Beake's account of Abyssinia. But certainly we knew no more about its geography when we left the room than we did when we came into it.”

10th February, 1844 :—

“ I had a very complimentary note from the Foreign Office last night, about Captains Robinson and Pison and my sappers that I sent from the Survey to settle the American Boundary.”

And on February 21st :—

“ I have just been reading two very amusing and cheerful letters from my officers, Captains Robinson and Pison, who are at work with some of my soldiers on the American Boundary. They cannot tell the degree of cold because the mercury is in the bulbs of all the thermometers. It is, therefore, more than 32 degrees below freezing ; and they are obliged to keep all the chronometers in a room with a fire, and a sapper to repeat the *ticks* loud for them to hear in the observatory, because it is too cold in the observatory for the chronometers to go.”

Colby was a man of religious temperament and took a lively interest in church affairs. He deplored the state of things that then existed in Wales. Being also a man of science, he had no patience with those ecclesiastics who ignored, decried, or derided the conclusions of organised knowledge ; and it may be remembered that in his day the new teachings of geological discovery were beginning to be appreciated by the public. On February 27th, 1844, he writes :—

“ I met a gentleman who has property at Cheltenham yesterday evening. He was giving me an account of the ignorant bigotry of Close, and his violent attacks on science.”

On March 25th :—

“ Wales will be improved *in spite* of the Welsh [Colby was himself Welsh].

Again, with regard to the church in Wales :—

“ I feel convinced that the whole government of the Established Church requires a change, and regret that the clergy are the last to see the necessity for a reform.”

Whilst the Survey of Ireland was in full swing, Colby's permanent house was Knockmaroon Lodge, although he was, for long intervals, in London, looking after the interests of the work. In 1838, when the survey of Scotland was resumed, Colby left Ireland and lived in London. In October, 1841, the Survey offices in the Tower of London were burnt down, and in 1842 the headquarter offices were removed to Southampton. From this year until his retirement in 1846 Colby lived principally at Southampton. Colby's retirement took place at the moment when the last of the Ordnance maps of Ireland on the six-inch scale had just been completed and published.

It appears from a letter written by Sir John Burgoyne that Colby voluntarily retired, after being promoted to the rank of Major-General. It was not the case that he left the Survey on account of his promotion, but rather that he thought it time to take a rest from the prolonged labours of forty-four years. After leaving the Survey he took his family to Germany and Belgium, in order to educate his sons. He was not well off, but had taken the unusual step of relinquishing his salary for the last five years of his active employment. It is said that :—

“ Colby did not hesitate, year after year, to take upon himself the responsibility of exceeding by large sums the rates sanctioned by Parliament, rather than diminish the rate of expenditure and progress by discharging qualified assistants. To keep down current expenditure, Colby for some time did not draw his own salary. When he subsequently applied for arrears they were refused and never paid.”*

This statement is borne out by a letter from Richard Mudge of the 20th July, 1848 :—

“ MY DEAR SIR,

“ If anything has given me more surprise than for a very long time, it is the fact you mention, and which I learned for the first time from your letter that the Board of Ordnance had withheld your salary for the Survey of Ireland for the last five years preceding your quitting the Survey. It is so unjust and absurd that I am sure it must eventually be paid, although it may require the interference of some person of weight and influence with the present Government to obtain it. I think that your claims are of a much greater amount. . . The Survey of Ireland is one of the most important and successful undertakings of late years and was conducted throughout and to what may be termed a conclusion by a continuation of firmness and perseverance which I assure you always impressed me with pleasure and admiration. I knew a great deal of what you had to contend with and of some of the difficulties and impediments that were thrown in your way.” . .

However, he never got the whole of his money back, though it appears that he was repaid a small fraction of it.

* *Dictionary of National Biography. Article, Thomas Colby.*

One of the many advantages of Colby's long residence in London was that he became very intimately connected with the various scientific societies which have their headquarters in the metropolis. He was a Fellow of the Royal Society. He was an original member of the Royal Astronomical Society, and helped to draw up its rules. He assisted at the formation of the Royal Geographical Society, and was a Fellow of the Geological Society. He was an Honorary Member of the Institution of Civil Engineers and frequently attended the meetings of that body. He was given the honorary degree of LL.D. by the University of Aberdeen. But, except for promotion to Major-General, he never received any recognition from the various governments that he had served.

Colby had a wide circle of friends and correspondents. Amongst soldiers, Hardinge, Fitz-Roy Somerset (afterwards Lord Raglan), and Burgoyne, Pasley and Everest; amongst sailors, Raper, Hurd and Beaufort; amongst men of science, Banks, Faraday, Airy, Kater, Brewster, Murchison, Herschel, Baily, Hutton, Sheepshanks, Sir W. Hamilton, Sedgwick, De la Beche, Peter Barlow and Gregory; and in the larger world, Rowland Hill, Robert Stevenson, the engineer, Lord Macaulay, and Sir Thomas Brisbane. He was clearly happiest in the atmosphere of learning, and never more at home than when in the company of his friends of the learned societies, at the various dining clubs to which he belonged, or when taking part in the proceedings of these societies.

The unsettled state of affairs on the Continent induced him to return to England with his family in 1848, and a few years later "with little or scarcely any warning, the spirit, yet active, was summoned from the body, yet firm and hale, and on the 2nd October, 1852, in the 69th year of his age, whilst amid his loving and mourning family, at New Brighton, near Liverpool, he passed from the scene of so much bodily and mental exertion to rest and peace eternal." * Portlock goes on to say that he learnt to appreciate Colby's "accurate knowledge, his sound judgment, his untiring energy and consummate skill, and, above all, his unbounded liberality in imparting to me and others the stores of his own knowledge."

One more tribute to Colby's memory may be given: that written by Sir George Airy, the Astronomer Royal. Airy and Colby were friends and had been in close touch for a great number of years. Colby knew how to value Airy's great gifts, and Airy was ever ready to help the Survey. There is no trace of the hard and unpleasant side of Airy's character in his relations with Colby or the Ordnance Survey. Airy writes in 1869 to Mrs. Colby:—

"We both were members of the Board of Longitude, which was dissolved in 1829 (I think). . . At one of my Irish visits I had the happiness

* Portlock's *Memoir of General Colby*.

of enjoying the hospitality of Knockmaroon Lodge ; and in later years, when Colonel Colby was for a long time fixed in London, I and my family had the gratification of receiving him very often at our Sunday dinner at Greenwich. We can all bear testimony to his kind and social disposition ; his appearance was always a source of friendly pleasure to us. I was often struck with the peculiar adaptation of Colonel Colby's talents and habits to the great work which he directed and the great system which he principally created. With the scientific geodetic problem before him he was familiar. On the grand points of execution, such as the large scale triangulation (I may well use that epithet for a triangulation which described the length of Ireland in three steps and its breadth in two), he was clear in his own judgment and decided in his provisions for carrying them out. . . The order of his offices was admirable. His attention to the accuracy of instruments of every kind was very great. And all this devotion of himself to his great work appeared to be wholly unselfish. I never heard a word from him which implied that he was looking abroad for personal glory, or for any expression except the recognition of his results as producing a scientific survey superior to any that had ever been made, and a cadastral mapping to which no other, I believe, can be compared."



MAJOR-GENERAL THOMAS COLBY,

R.E., LL.D., F.R.S., &c.

1784—1852.

Director of the Ordnance Survey,

1820—1846.

VIII. THE SURVEY OF IRELAND.

The Seventeenth Century Surveys of Ireland.—The modern Ordnance Survey of Ireland was begun in 1825, but this was by no means the first official survey of the country, even if we restrict the meaning of the word to the measurement of the land and its boundaries and the making of maps from such measurements. Of course, in a certain broad sense, even such an examination into the condition of a country as resulted in the Domesday Book is a survey, and is so quoted by the Select Committee of 1824. But in the seventeenth century the obvious convenience of making maps to illustrate such an investigation was fully realised, and we find that Strafford, who was Lord Deputy of Ireland from 1633 to 1639, caused maps to be attached to his surveys of Tipperary and other countries. In a report on the Strafford survey of Tipperary made to the Commissioners of the Commonwealth, it is stated :—

“ We have perused certain small books bound up in parchment . . . on the outside of which books are set down . . . the names of the parishes respectively belonging to that baroney. In the inside of the books, before every parish, are set down the names of the jurors, being generally six in number, and underneath the said names, this memorandum within, that they being all duly sworn upon the holy Evangelists, have set forth the bounds and meares, names and by-names, of all the quarters, plow-lands, and other denominations of lands lying in the parish, together with all the owners and proprietors of the said lands. . . In the next place is sett downe the names of the surveyors who admeasured the said parish . . . the method and proceeding in the description of every parish is as followeth :—

- 1st The number of surrounds made by the instruments, in each parish respectively. . .
- 2nd A description of each surround, more particular, according to the name of the land so surrounded ; the quality of the said land. . .
- 3rd At the end of each surround is an observation made of what castles, houses, mills or other edifices, as also what offices or other emoluments were found upon it.

“ We further humbly certifie that, besides the sayd bookes, wee find a very fair county map, containing the several barronyes . . as also smaller maps of particular barronyes, and of particular parishes, most of which, soe far as we can discover, are very entire and perfect. The said plotts or maps expressing also the quality of the said land, whether arable, pasture or meadow, etc.”*

* Quoted in Portlock's *Memoir of General Colby*.

Seventeenth century mapping work was fairly accurate when the area mapped was not very large. A seventeenth century parish survey would not differ much from a modern exact survey. The surveyors of that age were well accustomed to the accurate use of the chain in measurement; they were also acquainted with the uses of plane-table, compass, and circumferentor. The latter instrument had, however, no telescope, and was only provided with "sights"; and, of course, the arcs were not very finely graduated. Given the instruments available, they made as good traverses as we, perhaps, should. But, with such instruments, considerable errors accumulated in the traverses of large areas. There exist many admirable property plans dating from this period; the "platts" or "plotts" of parishes, or small properties, stand comparison with modern plans fairly well. Our ancestors of eight or nine generations ago were by no means as unintelligent as we are sometimes inclined to suppose.

The best known of all the early surveys of Ireland, and the first comprehensive large scale official mapping ever undertaken in the British Isles is the Down Survey.

The Down Survey.—This celebrated survey was undertaken to enable a systematic "plantation," or settlement, of English soldiers and adventurers, to be carried out in Ireland. Such a plantation, detestable as it is from a modern point of view, is a proceeding which history often has to record. In the case of Ireland it was Queen Mary who carried out the first systematic plantation, namely, that of Leix and Offaly; and from this example it is clear that religious differences were not necessarily a primary cause of such a policy. The settlement which necessitated the Down Survey did not take place for about a hundred years after Mary's plantation, and was a sequel to the "Rebellion" of 1641, which largely did take the form of a war of religion. For eight years after this date, Anglicans, Presbyterians and Roman Catholics, adherents of King, or Covenant, or Commonwealth, butchered each other with a ferocity inspired by racial and religious hatred. Then, in 1649, Cromwell came over with his disciplined army, and the rebellion was shortly at an end.

In the year 1653 an Act was passed, under the Commonwealth, for the *Satisfaction of the Adventurers for Lands in Ireland, and of the Arrears due to the Soldiery there, and of other publique Debts*. In the preamble it is stated that:—

"Whereas many well-affected persons, bodies politique and corporate, did subscribe and pay in, upon several Acts and Ordinances of the late Parliament, divers considerable sums of money by way of adventure towards the suppression of the late horrid rebellion in Ireland, which said sums of money were, by the said Acts and Ordinances, appointed to be satisfied by several proportions of the lands of the rebels there,

as soon as the said rebellion should be appeased; and whereas also several other great sums of money are grown due, and in arrear unto the officers and soldiers who have been employed in reducing the said rebels, and to sundry other persons either for arrears yet unsatisfied, moneys lent, or provisions or other supplies furnished for the publique service; and whereas by the blessing of God upon the forces of this Commonwealth, the said rebels are subdued, and the said rebellion is appeased and ended, and it is hereby declared to be appeased and ended."

The Act appointed a Committee in London for "the drawing of lots for ascertaining to the said adventurers where their dividends of lands shall be," and a Commission in Ireland to arrange for the distribution of the lands. In the Instructions to the Commissioners full power and authority was given to them to put in execution all the necessary steps for the "exact and perfect survey and admeasurement of all and every the honors, baronies, castles, manors, lands, tenements, and hereditaments forfeited," as also those belonging to the Crown of England or the Church; and a surveyor-general and assistants were to be appointed.

An order was then issued, putting Mr. Worsley, surveyor-general, and Doctor William Petty, jointly in charge of the work: "It hath also been ordered that Benjamin Worsley, Surveyor-General, and Doctor William Petty, should be joyntly authorized and empowered to carry on the said work, and to imploy such fitt and able artists in it as they should think fitt." They were to survey the lands belonging to the rebels,

"in the County of Lowth and the County of Leitrim, and also all the lands, tenements and hereditaments of, or lately belonging to all and every the rebels in any of the baronies within the County of Cork, Kilkenny, Longford, Lowth, Cavan, Monaghan, Ffermanagh, Sligo, and Mayo. . . You are to survey, or cause to be surveyed and admeasured with the instrument, all the lands mentioned . . . You are carefully to survey and admeasure with the instrument the out-meares and bounds of all and every the baronies within the counties mentioned. . . You are to give into the office of the Surveyor-General fair plotts and bookes of survey . . . together with bookes of references answering to the said plotts, in which you are at large to describe the boundes and metes of all the said forfeited townes and lands . . . and to set down what you find observable in them." . .

Doctor William Petty was born in 1623, and was the son of a clothier at Romsey, in Hampshire. In 1652 he was appointed physician to the Army in Ireland, and thus came into touch with the question of the survey of the forfeited lands. Before his arrival in Ireland, and before the appointment of the Commission mentioned above, it would appear that Worsley, the Surveyor-General, had been carrying out some surveys for the purpose. Dr. Petty had a poor opinion of Worsley's methods, and proposed a system of his own, which was accepted. He was given the contract for

the operation, and made a fine fortune out of it. The work was, considering the methods and instruments available, admirably carried out, and in a short space of time. The difference between Worsley's scheme and that of Dr. Petty was, briefly, that Worsley worked on the unsound principle of surveying small "surrounds" and fitting them together without adequate checks; whereas Dr. Petty realised the importance of working, as far as possible, downwards, from the whole to the part, and of establishing checks at every stage of the survey. He does not appear to have made use of triangulation, although the method was known at the time, having first been employed by Willebrord Snell, in Holland, in 1617.

Sir Thomas Larcom, in his history of *The Down Survey*, says that :

"Worsley was carrying on the survey for grants and forfeitures . . . but it remained for Dr. Petty to originate the idea of connecting the separate operations into a general survey of the three provinces which were not comprised in the Strafford Survey. His great step was making territorial and natural boundaries the main objects, instead of estate boundaries alone."

Dr. Petty introduced a system of checks into the method of carrying out the surrounds or traverses. He instructed the surveyors,

"by intersections, to determine the true place of all townes, churches, castles, known houses, mills, raths, etc., within each respective surround . . . for the better examining and correcting your works." He also laid down the rule that "the common lines of each barony are to be run together by two distinct measurers at once, their respective servants keeping double reckoning of the chains alsoe." Again, "as often as conveniently you can, you shall protract your large surrounds before you doe the inworke of the same."

Most of the barony maps are on the scale of 160 Irish perches to one inch, or 1.6 inches to one mile. But about a quarter are on the scale of 0.8 inch to one mile, and a few on the 3.2 inch scale. The parish maps, from which the barony maps were reduced, were on the scale of 3.2 inches, or 6.4 inches, to the mile.

With regard to the name *Down Survey*, the work was apparently so called because it was set "down" on paper. The expression is used in both the reports of the Committee on Dr. Petty's proposal issued in 1654. Dr. Petty's surveys were carried out in two parts. The first for the settlement of the Cromwellian soldiery, under an agreement between Worsley and Petty, dated December 11th, 1654, and the second for the settlement of the "adventurers," under an Order in Council of September 3rd, 1656.

Until a few years ago it had been supposed that the most authoritative copies of the original barony maps were preserved in the *Bibliothèque Nationale* at Paris, but the Earl of Kerry

has shown that most of the originals exist and that the bulk of them are amongst the papers of the Marquises of Lansdowne.

"The maps were at Lansdowne House in an old chest, where, to all appearances, they had long rested. With them were also found some letters and memoranda which show that they had been in Dublin, in the hands of the first Lord Lansdowne's agent, at the end of the eighteenth century. It seems probable that they were sent over to London after his death, and that they have remained there ever since. There can be little doubt that they form a portion of the original survey maps bequeathed in his will by Sir William Petty, of whom Lord Lansdowne is a lineal descendant."*

More than half of the original Down Survey baronial maps are in the Lansdowne collection; almost all the remainder are in the Public Record and Quit Rent Offices in Dublin. The barony maps were never engraved, but were used in the preparation of county and provincial maps. With regard to the French copies, Lord Kerry writes:—

"As is generally known, there are in the *Bibliothèque Nationale* at Paris two large volumes of these barony maps, which, though long recognised as copies, are important as constituting the only complete set in existence. They comprise all the baronies of Ireland (215), except those of Roscommon, Galway, and parts of Clare and Mayo, which counties having been surveyed under Strafford's administration, and afterwards reserved for the transplanted Irish, were not dealt with in the Down Survey."*

The two volumes of the Down barony maps in the *Bibliothèque Nationale* in Paris have a curious history. They were copies of the original maps, and were, apparently, being sent from Ireland to London to be engraved, when they were captured by the French at sea in 1707 and found their way to the *Bibliothèque Royale*. In 1786 King George III. asked that they might be restored to Ireland, but the French Government refused. They were, however, copied by hand and the copies are now in the Public Record Office. Photozincographic reproductions of these copies were made, in later years, at the Ordnance Survey Office, Southampton, where these reproductions can be purchased.

The Select Committee on the Survey and Valuation of Ireland.—This Committee, which reported on the 21st June, 1824, had specially in view the more equal apportionment of the local burthens collected in Ireland. The Committee reported that there were great variations in the methods of assessing the local taxation, and that the assessment was inequitable because areas and values were inaccurately reckoned. Townlands, ploughlands, gneeves, cartrons, tates, and other denominations of land are

* Proceedings of the Royal Irish Academy. Vol. XXXV., Section C, No. 12, 1920. The Lansdowne Maps of the Down Survey, by the Earl of Kerry.

mentioned ; and it is stated that however the names might vary, the evil seemed universally the same, and that the inequalities had continued for a very long period to the year of the report. It was stated, also, that a Select Committee of 1815 had reported in favour of rendering the assessments more equal, by correcting the defects arising from the fixing of the county rate according to the old surveys, calculated on land values altogether out of date.

The report mentions the Down Survey in these terms :—

“ The most extensive and valuable survey of Ireland was undertaken by Sir William Petty, under a commission dated December 11th, 1654 ; it was executed in consideration of a payment of 20s. by the day, and of 1d. an acre for the grantees obtaining possession of the lands. This survey was laid down with the chain, and with wonderful accuracy, considering the period at which it was executed.”

It is added that the last official survey (up to 1824), of an extensive nature, made in Ireland, was that of the Forfeited Lands, in the reign of William III ; it comprised about two million acres.

The area of Ireland was stated to be about 12 million Irish, or about 20 million English, acres, divided into four provinces, 32 counties, 252 baronies, and 2,400 parishes, with further civil sub-divisions, generally known as townlands. These latter “ are the ancient and recognised divisions of the country ; they form the basis of the Down Survey ; they have long been used ” for the assessment of local rates. The Committee, therefore, reported that any new Survey must give the boundaries of the townlands. Major Colby gave evidence that the additional time required to plot the townland boundaries on the map would not be very considerable, provided that the boundaries were previously set out on the ground ; and Mr. R. Griffith stated that there would not be any great difficulty in ascertaining the boundaries in question. It may be noted that townlands were of very varied sizes, but were most frequently in the neighbourhood of two or three hundred acres.

At this date, 1824, the materials available for assessment were : The Down Survey and the Strafford Survey of the seventeenth century, with some modern surveys in a few cases. No doubt the modern survey of Roscommon, executed by Mr. W. Edgeworth and Mr. R. Griffith was a good one of its kind, but such surveys were few and far between. As to the seventeenth century surveys, not only did they lack the precision to be expected from modern work, but the assessments based upon the ancient values of the land were often very inequitable. The Chairman of the Committee, Mr. Spring Rice, said that, as regards the County of Limerick, where he resided, the contents of the rating book were based upon ancient estimates, which did not agree entirely either with the Down Survey or with any other authority which he knew to be in existence. He also said that there was a general feeling in favour of the old

established boundaries, namely, those of baronies, parishes and townlands; they had been, in many cases, ascertained by judgments in courts of law, "and they form the foundation of the Down Survey now in existence, and the best document of the kind which can now be referred to in Ireland." He expressed the opinion that there was no remedy for the evils complained of, "except through the means of a new survey and valuation."

Colby's evidence before the Select Committee is valuable, because it shows the general ideas which he had upon the subject of a large scale survey, before he was actually required to organise such an undertaking. He said that he thought they could complete 2,000 square-miles of survey during the first year and an increasing area in subsequent years. In his opinion a scale of six inches to the mile was large enough to show those divisions of land, called townlands, which varied from 50 to 400 acres. It is interesting to note that he had then no knowledge of the Down Survey. He was opposed to officers of Engineers taking any part in the valuation of the land surveyed. He gave evidence that the work would take at least seven years and would require 25 to 30 officers, with five or six surveyors to each officer. We may say, in fact, that, making allowance for labourers and office staff, he seems to have contemplated an establishment of about 400 officers and men. As a fact, he under-estimated both the time and the establishment necessary.

He was not favourable to the idea of employing surveyors temporarily, and he insisted on the whole staff being under efficient control. He would not accept the idea of allowing the boundaries of the townlands to be surveyed by local surveyors and then fitted on to a scientific framework; he stated that he could not construct a map by fitting townland surveys together and he gave evidence that the cheapest, most rapid and most accurate method of making a large-scale map of Ireland would be to create an organisation for the express purpose and to give up any idea of adapting local surveys.

In all these general considerations his advice was undeniably sound, and it was almost immediately acted upon.

A surveyor called Hyett gave some curious evidence. He had been employed under Mudge some years before, on the survey of the detail for the one-inch map of England; and he says that, "the corps of surveyors, of which I was a member, being disbanded, I was appointed professor of military drawing to the Royal Military College, and one of my duties was to instruct the cadets in surveying and sketching." The corps of surveyors and draughtsmen had, thus, ceased to exist before 1824. Hyett gave the remarkable advice that the survey of the detail should precede the triangulation! Fortunately, no one else was of that opinion.

Mr. W. Edgeworth, the celebrated engineer, gave an interesting account of his surveys of the counties of Longford and Roscommon, and also produced specimens of the large-scale maps of Bavaria. These were on the scale of 1 : 5,000, or about 12 inches to the mile, and were based upon primary and secondary triangulations, the filling up of the interior being "completed by a peculiar species of plane-table and in order to do away with the inaccuracies of the common chain, the triangulation is carried down on paper to the most minute corners of fields." The Committee also mentioned the French 1 : 2,500 *cadastre*, which may be said to have commenced in 1803 and was costing about £120,000 a year. This sum frightened the Committee, which stated that "the delay of the work as well as the increase of expense, seem to have been the result of the minuteness of the survey, which extends to every distinct field; a minuteness which, for many reasons, your Committee consider to be unnecessary and inexpedient to be sought for in the proposed Survey of Ireland."

Before the appointment of this Committee, the House of Commons had, in the same year, 1824, voted £5,000 towards the execution of a Trigonometrical Survey of Ireland, and had resolved, "that it is expedient, for the purpose of apportioning more equally the local burthens of Ireland, to provide for a general Survey and Valuation of that part of the United Kingdom." The Committee had now to make definite recommendations.

Recommendations of the Select Committee of 1824.—

"Whilst your Committee express their belief that the execution of the survey cannot be placed in better hands than in those of the Ordnance Officers, they cannot but add, that it is expedient to give much greater dispatch to this work than what has occurred in the Trigonometrical Survey of England. That great work, highly creditable as it is to the individuals by whom it is conducted, has already been 33 years in progress, and yet it still wants one-third part of its completion. It ought to be added, however, that the operations of the Ordnance suffered interruption during the war." . . .

"Your Committee perfectly agree with Major Colby that a central and effectual control is indispensable." . . .

"The best scale for effecting the intended Survey appears to your Committee that of six inches to the English mile." . . .

"The new Survey should supersede all local topographical proceedings, whether under the authority of Grand Juries or otherwise."

The Committee also reported that they had considered what should be shown on the maps, and they stated that a survey showing the boundaries of baronies or parishes would not be detailed enough, whereas a "Survey by Fields" would be too expensive and slow. They, therefore, advised the survey of townland boundaries, but not a field to field survey. This restriction was subsequently removed.

After again pointing out the necessity for proceeding as rapidly with the work as would be consistent with accuracy of execution, the Committee concluded :—

“ It is not unworthy of remark that all former Surveys of Ireland originated in forfeitures and violent transfers of property ; the present has for its object the relief which can be afforded to proprietors and occupiers of land from unequal taxation. . . In that portion of the empire to which it more particularly applies, it cannot but be received as a proof of the disposition of the Legislature to adopt all measures calculated to advance the interests of Ireland.”

The Ordnance Survey of Ireland is Begun.—Armed with the authority of Parliament, the Board of Ordnance, under the Duke of Wellington, took immediate steps to commence the 6-inch survey of Ireland. But, already, in 1824, Colby had been over in Ireland, “ to acquire a general idea of the country, and to seek a proper place for the measurement of a new base line.” For this purpose Colby chose a site in County Londonderry on the eastern shore of Lough Foyle. The base was not measured until 1827-28.

Meanwhile, the triangulation was started. Whilst the trigonometrical work in the south-west of Scotland had been in progress, various hills in Ireland had been marked by signals and were linked up, by intersection, to the Scottish hills. These hill stations extended from the Mourne Mountains in County Down to Malin Head in Donegal, along some hundred-and-fifty miles of the north-east coast of Ireland. Of the hills used, Colby particularly mentions the importance of Divis, near Belfast, “ the triangles of which it is the apex cover a space of about one hundred-and-thirty miles in one direction and about eighty miles in the other—no less than two hundred Trigonometrical Points were observed from it.” In 1825 an accurate survey was made of the level stretch of ground on which the Lough Foyle base was, later on, measured.

Colby's first report to the Board of Ordnance on the General Survey of Ireland is dated 2nd February, 1826. In this he states that the officers employed on the six-inch survey of Ireland were supplied, in the beginning of the summer of 1825, with trigonometrical distances computed from observations made at the stations in Scotland, in order that no delay in the detail survey might occur. In this report he mentions Drummond's two inventions, namely, the heliostat and the limelight.

“ The first is a Solar Reflector so ingeniously contrived that a soldier is capable of directing it with certainty and facility. . . The first [trial] made with the Solar Reflector was on the Divis, to be observed from Knock Layd, a distance of about forty miles. At this distance it was brilliantly seen with the naked eye at a time when the mass of the mountain was barely visible. . . Some notion of the light given by the

lamp may be formed from the circumstance of its appearing more brilliant to the naked eye at the distance of upwards of sixty-six miles [from Slieve Snacht in Inishowen] than another lamp placed at a distance of about fifteen miles . . . the latter being of the description commonly used in lighthouses."

"To complete these trials and to furnish the necessary distances for the local Survey, the Officers and Men continued encamped on Mountains from 1,500 to 2,000 feet above the level of the sea, till towards the latter end of November and beginning of December, and much praise is due to them for the willingness with which they endured the personal inconveniences of exposure on those high situations at that inclement season of the year."

Formation of the Survey Companies.—Until the year 1825 most of the manual labour required in the operations of the triangulation had been supplied by detachments of Artillerymen. This employment of soldiers had been fully justified, both on the score of cheapness and on account of the steadiness imparted to the survey by Army discipline. Colby, when faced with the problem of organising the Ordnance Survey of Ireland, was satisfied that he could not do better than employ soldiers, even more freely, in this new extension of the work. He says :—

"When this Survey was proposed, a large portion of the Engineer Corps was unemployed, and I conceived that the whole of the soldiers in the Corps of Sappers had gone through a course of practical geometry, etc., under Colonel Pasley at Chatham. It appeared a regular Military Body might be formed from these sources, who would soon become capable of executing the greater part of the work, and that the deficiencies might readily be supplied as occasion required. The formation of this Military Body from the Corps of Engineers and Sappers during a period of profound peace, when few adequate objects were presented for the exertion of those peculiar talents which fit them for the duties expected in time of war, seemed to me to possess great advantages with regard to the Corps themselves."

Colby is here talking of the two Corps of Officers of the Royal Engineers, and of the men of the Royal Sappers and Miners, then distinct bodies. He goes on to say that :—

"As far as regarded the advancement of the Survey itself, two circumstances seemed in favour of this arrangement ; the one the unity of the system and facility of direction arising from military discipline, and the other the nature of the information already attained by the officers and soldiers. . . By the Military Body the whole of the work will be performed according to regular instructions, and it is probable that every part will be executed with equal accuracy, at least the instructions are so devised that the work itself will afford facilities by which its errors, if any, may readily be detected and traced to their sources. . . After the Military Body has acquired experience it will also have the further advantage of carrying on the work with much greater celerity than it could have been carried on by the hire of Surveyors."

The Duke of Wellington approved of Colby's scheme, and Colby was given a free hand to select officers and men ; his only difficulties with regard to the officers being his want of acquaintance amongst the officers and the smallness of the Corps itself. With regard to the men, it was found that those soldiers of the Corps of Royal Sappers and Miners who could read and write, and had passed through the course of practical geometry at Chatham, proved excellent material for the new companies. But it was also found that so many men had been enlisted in the Corps who could neither read nor write, that the formation of the three companies authorised was delayed. Colby remarks that " the Artillery recruit very much in Scotland and the North of England, where the spread of education is much greater than it is in South Britain. Twenty-four years' experience on the mountains has enabled me to observe that the Artillery are generally intelligent, hard-working men and good, obedient, trustworthy soldiers." This latter remark was made with reference to an idea, not carried out, that the personnel of the Survey Companies might be filled up by transfers of Artillerymen.

Colby gives the following *Chronological View* of the formation of the Survey Companies :—

- " 1824. 1. August 28th.—I proposed the first Surveying Company officially.
2. September 22nd.—Surveying Company ordered. [13th Coy. R.E.]
3. November 26th.—First detachment of Surveying Company went to Chatham.
4. December 8th.—Surveying Company complete at Chatham.
1825. 5. March 18th and 31st.—Surveying Company went to Ireland.
6. February 16th.—Second Surveying Company began to assemble at Chatham. [14th Coy. R.E.]
7. July 16th.—Part of Second Surveying Company sent to Ireland. N.B.—The greater part of these were taken to supply the place of the Artillery on the Trigonometrical Survey.
8. December 27th.—Another part of the Second Surveying Company sent to Ireland. N.B.—It is still incomplete. (January 30th, 1826.)
9. September 10th.—Third Surveying Company ordered. [16th Coy. R.E.]

Throughout this period of the formation of the Survey Companies, Colby was in constant correspondence with Col. Pasley, who commanded the School of Military Engineering at Chatham. These two officers were always on excellent terms, and Pasley materially helped in the creation of the new military establishments of the Survey. He wrote to Colby on the 19th February, 1825 :—

"I have received a number of Men, who, I think, will form a very good Nucleus to the 2nd Surveying Company, which will be numbered the 14th. I have to request that a Captain and a First Lieutenant may be named for it as soon as possible. Dalton has exerted himself so much in forming the 13th that I expect that much emulation will arise, and the Duty of Instruction of the 14th Company will be well done, when Officers are appointed. . . . I will do everything to forward the Service of the 14th Company, but the sooner the Permanent Officers join the better."

On the 23rd July, he writes to Colby :—

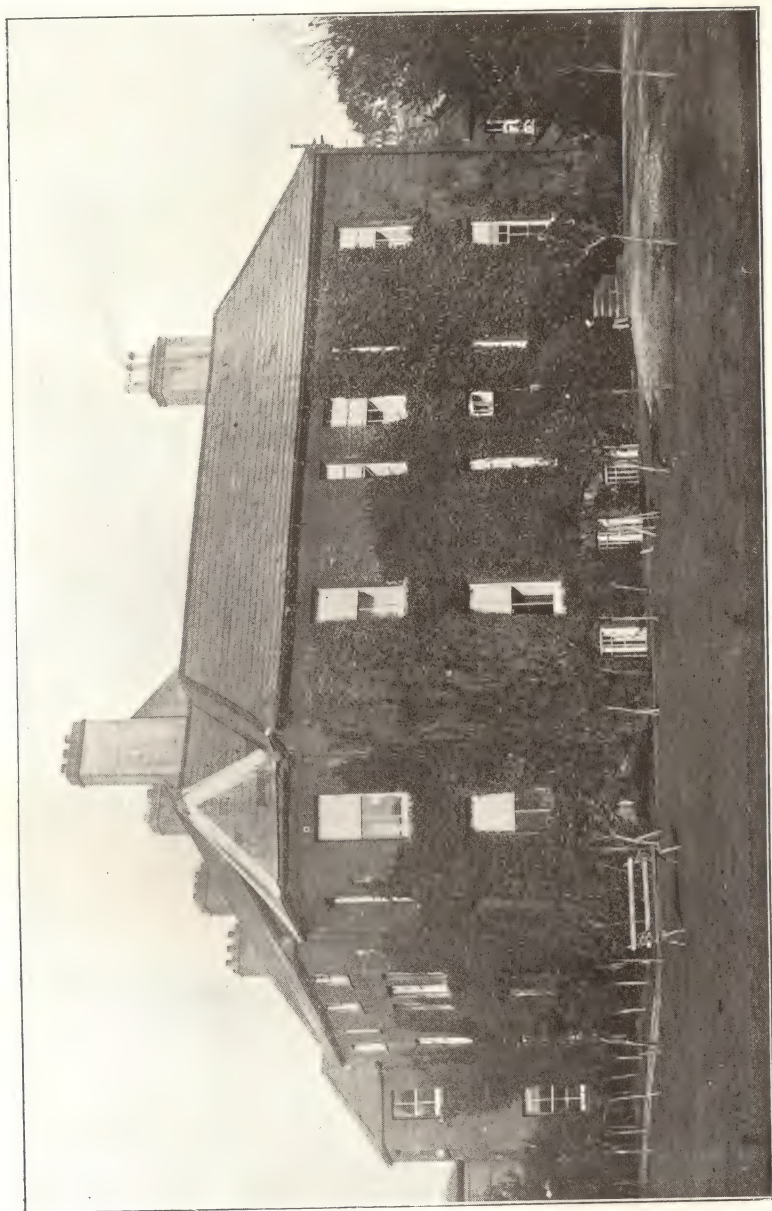
"I take this opportunity of requesting that you will restore their Arms to the men of the 13th Company. From my experience in the Military Duties of the Corps, I am quite persuaded that the Men of that Company will be ruined as Soldiers, and lose not only their own *Esprit de Corps*, but will be disgraced, or say *completely lowered*, in public estimation unless their arms be restored to them. . . . The 13th and 14th Companies . . . are each organised military bodies; and if deprived of their arms, I am sure that the evil consequences I prognosticate will follow.'

And again, in August, 1825, Colby having made some objections as to the political capital that might be made out of soldiers under arms being engaged on the work, Pasley replies :—

"Peaceably employed in surveying . . it must be quite impossible for them to come in collision with the People of the Country at all. I sincerely hope that you will take an early opportunity of restoring their Arms."

In this controversy it cannot be doubted that Pasley was right and Colby was wrong. Colby seems to have admitted the error; anyway, the men of the Survey Companies have always had their arms like other soldiers.

Some Details of the Administration.—On the 7th April, 1826, the total strength of the Survey establishment was 203, made up of 28 officers, four candidates and cadets, 106 sappers and miners, and 65 labourers. The total expenditure for the year 1825 was £16,218, and for the half-year, January-June, 1826, £9,560. We may say a strength of 200 and an annual cost of about £20,000. The rates of pay were low, "inferior assistants," or labourers, to drag the chain, receiving from 9d. to 2s. a day; the 9d. rate being probably given to boys on probation. There were originally no superior civilian assistants, except one clerk on 2s. 8d., and two draughtsmen on 4s. a day. The officers and sappers received survey pay in addition to regimental pay. The field work was concentrated in the north of Ireland; at the end of 1826 there was a Headquarter Division at Mountjoy, Phoenix Park, Dublin, under Major W. Reid (afterwards Sir William Reid, Governor of Malta); and five survey districts at Belfast, Coleraine, Londonderry, Maghera and Lisburn, under Captains T. F. Lancey, P.



Mountjoy, Phoenix Park, Dublin.
Headquarters of the Ordnance Survey of Ireland, from 1825.

Yule, M. A. Waters, C. Wright, and Lt. English, respectively. In addition to the officers at Mountjoy and in the five districts, we must reckon those employed on the triangulation—Portlock, Drummond, Larcom, James and others. There were five Artillery subalterns on the strength of the Survey.

Mountjoy House.—An admirable house was selected as the headquarters of the Ordnance Survey of Ireland. Mountjoy stands in Phoenix Park, in sixteen acres of its own grounds. It is a substantial comfortable house, just the kind of house that one might expect a well-to-do Irish gentleman to have built in the old days. It was, as a fact, built about 1728, by the Rt. Hon. Luke Gardiner, when he was Castleknock Keeper of Phoenix Park. His grandson became Lord Mountjoy, and was killed in the rising of 1798, when Colonel of the Dublin regiment. Musgrave, in his *Rebellions in Ireland* says that Mountjoy "had the gentlest manners, and the mildest affections, warm and sincere in friendship, and so benevolent and humane that he never harboured revenge." It is said that Mountjoy added a theatre to the house in 1778, in which *Macbeth* was acted. At the end of the eighteenth century the house was bought by the Government for the Secretary at War.

By 1812 the house had been turned into a barrack and the land adjoining was known as the Barrack Demesne. In 1825 the Board of Ordnance handed it over to the Ordnance Survey as the headquarters of the Survey of Ireland. Major Reid seems to have lived there; and certainly, in after years, the house was the dwelling place of successive officers, who had, under the Director, charge of the Irish Survey. Only part was used as a dwelling house. The rest was converted into offices for the various indoor operations of the survey; and, year, by year, other buildings grew up round it; barracks for the men, workshops, stores, machine shops, and so on, until it became a very complete establishment. It remained under the Director of the Ordnance Survey of the United Kingdom until 1st April, 1922, when the establishment at Mountjoy, with the rest of the Survey of the Irish Free State, was handed over to the Government of that State. The value of the buildings and machinery was then estimated at about £160,000.

Many an old Ordnance Survey official will retain kindly memories of the big, red house and the survey buildings amongst the trees, the home for a hundred years of much good work and loyal service.

Boundaries.—The chief and original object of the Ordnance Survey of Ireland was the marking exactly on paper the boundaries of counties, baronies, parishes and townlands, and the ascertainment of the areas of these divisions. From the beginning, Colby

refused to take any responsibility for the determination of the situation of these boundaries on the ground, only promising to survey them accurately when pointed out. The duty of ascertaining the boundaries of the ground fell to the lot of a Boundary Department, under Mr. Richard Griffith. Colby's early reports are full of complaints as to the way in which the Boundary Department carried out its duties. He says, in February, 1827, that that Department was "in a peculiarly defective state, and a great deal of time was lost through the want of proper Boundary Surveyors"; also, that he "found persons had been appointed as Boundary Surveyors who did not consider the duties they had to perform as of any great importance."

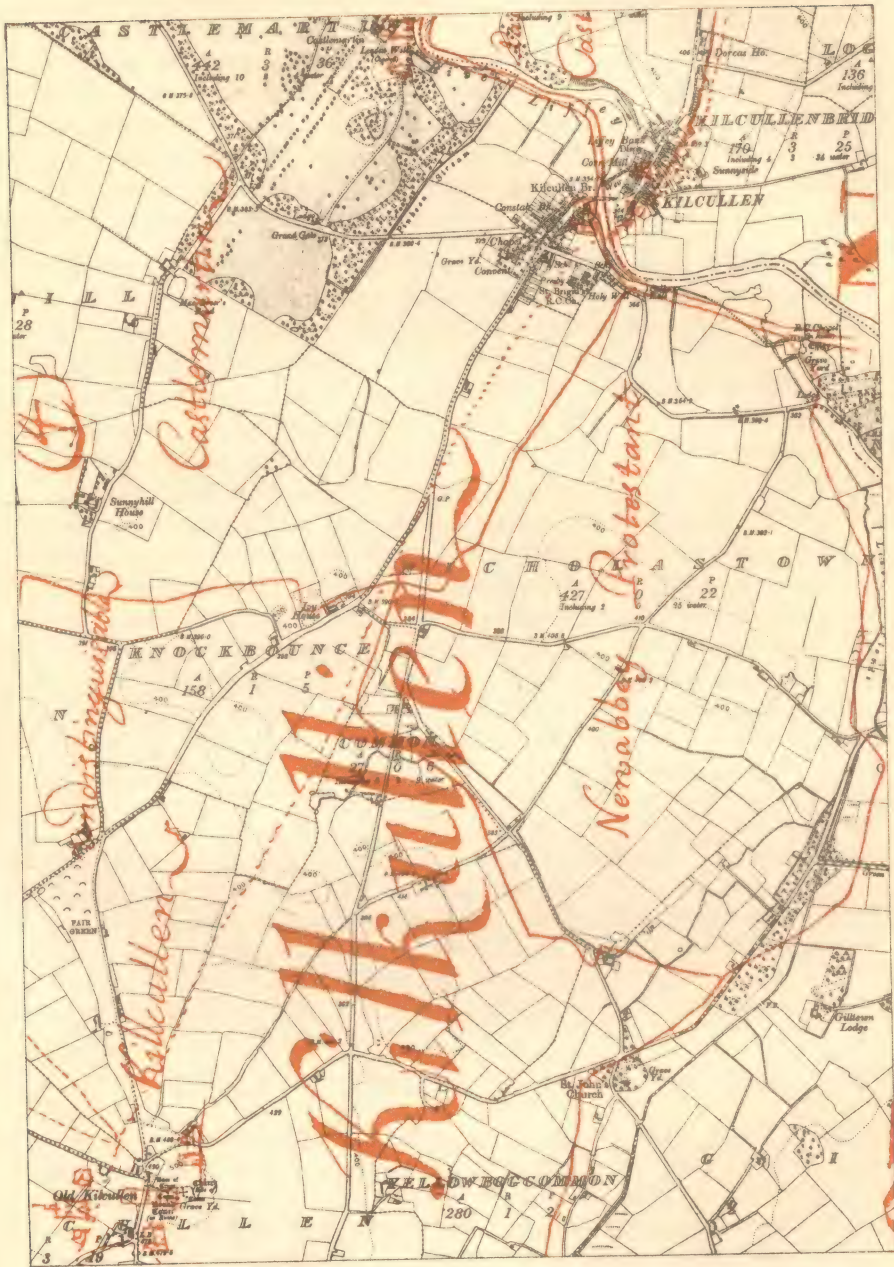
Some of the Meresmen, "being ignorant of the Boundaries, went round with my officers, enquiring of the inhabitants as they went along . . . and the boundaries were frequently pointed out wrong"; and again, "it is my virtual dependence on the progress, and correctness, of the Demarcation Department that renders it so extremely difficult for me to calculate the time required for the Survey." But matters improved, and, in February, 1828, Colby reported that, "the Boundary Department, under the direction of the Irish Government, is becoming much more effective, and is now nearly adequate to the present rate of progress of the Ordnance Survey." But it can hardly be said that Colby and Griffith worked altogether amicably together, even after this date. Thus, in a letter written by Griffith to Colby, and dated Sligo, September 26th, 1828, there occurs this passage:—

"According to the Arrangement entered into between the Irish Government and Sir Jas. Smith, I am only to be six months in advance of the Ordnance. Will Capt. Waters undertake to complete the survey of the whole of his present district within six months after November next, if not the arrangement will have been broken through by him, and any casualty among the meresmen or expense incurred by calling back the boundary surveyors from distant parts subsequently to that period must be charged to the Ordnance.

With regard to the allied question of the marking of property boundaries, the principle of the Ordnance Survey has always been to show any features visible on the ground, from which such boundaries may be measured or inferred, but not, except in the case of administrative divisions, to mark ideal, or invisible, lines. In a draft of a memorandum written by Colby about this period, it is stated that:—

"If any boundaries are to be inserted, those boundaries should be first rendered distinctly visible in the country by the erection of well defined marks of a nature sufficiently permanent to be appealed to in case the accuracy of the survey should be hereafter called in question. And if the Ordnance make a faithful representation of what can be seen

Down Survey of Co. Kildare 1655.



Scale:- 80 Irish Perches to 1 Inch or 3.2 Inches to 1 English Mile

Over-printed with the modern 6 Inch Map reduced to the same scale

in the country without inserting invisible boundaries . . . they will perform all that can be required of them."

It is a good, practical rule, not, in general, to show invisible boundaries, and it resulted from this rule that property boundaries, as such, are not shown at all. But since property boundaries depend on fences, walls, hedges and similar visible objects, there is no difficulty in using Ordnance maps as property maps, indeed they are universally used for this purpose; although the hedge or fence may not be the boundary proper, which often, indeed usually, runs a few feet distant from, and parallel to, it.

Colby's Intention with Regard to the Civil Staff.—Colby intended to form a military department, in which all the principal operations out-of-doors, and most of those in the office, would be carried out by soldiers. He contemplated, in addition to the officers and the survey companies, an establishment of labourers to drag the chain and do other work of a purely manual nature; but he had also in view an establishment of a few civilian engravers and some civilian draughtsmen to supplement the military draughtsmen. He complains, in a report written in February, 1828, that when he was necessarily away in England a kind of discretionary power was allowed to the branch office of the Board of Ordnance in Ireland, and that things were done in his absence of which he disapproved. He says,

"If no such Board [the Irish branch] existed, I feel convinced that the Irish Survey would not have been suddenly overwhelmed in the winter of 1826-27 with an influx of uninstructed civilians. And the disorganization and expense attendant on that violent local measure would have been saved. When I visited the Districts in October, 1826, it was observed to me that draughtsmen were wanted, and I certainly did desire the District Officer to look out for a few men who could assist in drawing. But how was this want supplied? Advertisements were put in all papers, unknown to me, and a great many persons were engaged who had everything to learn. . . . That this measure, so far as it produced for the Survey a few Civil Draughtsmen, was beneficial there can be no doubt, but thus far it was my intention from the very commencement of the Survey to adopt it."

The Royal Sappers and Miners.—In the same report Colby writes:—

"On the whole the Royal Sappers and Miners have proved a highly efficient force, and it is much to be regretted that they are not more immediately identified with their Officers by being called Engineers instead of Sappers, etc. They are deprived of the encouragement of being mentioned in Public Despatches by having no officers of the same name. And it cannot be doubted but the means of obtaining good recruits is greatly diminished by this apparently trivial circumstance of having to bear a long and obscure name which has no reference to the greater part of their duties.

Pasley says in a letter to Colby :—

“ The different name has been and is the greatest possible impediment to the Recruiting of the Corps. In fact it deters the men most qualified for our Service from entering it. I wish to God, that vile *labour-like* name could be abolished.”

The change of name advocated by Colby, and even earlier by Pasley, was not sanctioned until 1856. In the *London Gazette* for the 17th October, in that year, appeared the following notification :—

“ The Queen has been graciously pleased to direct, that the corps of royal sappers and miners shall henceforward be denominated the corps of royal engineers, and form one body with the existing corps of royal engineers.”*

The Lough Foyle Base, 1827-28.—As we have seen, bases, in the early operations of the Survey, were measured with wooden rods, or glass tubes, or steel chains. It now became necessary for Colby to consider how he should measure a base in Ireland ; for it was certain that a new base was required, not only on account of the distance of the Irish work from any of the previously measured bases, but also because it was desirable to stiffen the old triangulation and to attempt a higher degree of precision.

In 1825 Colby hit upon the idea of compensation bars ; the reason for adopting such a contrivance being that, in the measurement of a length with a metal chain or bar, an ever-present difficulty is the impossibility of ascertaining accurately what the temperature of the metal is. Colby, therefore, thought that the principle of compensation, which had long been in use in the construction of clocks, might be applied to the measurement of bases. As worked out by Colby and Drummond the base apparatus was thus designed.

Two bars, one of brass and one of iron, were laid parallel and close to each other. The bars were firmly connected at the centre, and were free to expand or contract from, or to, this point. Now, approximately, at ordinary temperatures, brass will expand .00001 of its length for every increase of 1° F. ; and, similarly, iron will expand .0000065 of its length ; so that the expansion of brass to iron is approximately as 100 to 65. If then, the ends of the bars are firmly connected by metal tongues, fixed to the bars by pivots, so as to allow the bar to expand, there will be a point on each tongue which does not move with reference to the central points of the bars. The immovable point will be about 100 units from the centre line of the brass bar, and 65 units from the centre line of the iron bar, the actual distances depending upon the space between the centre lines of the bars.

* *History of the Royal Sappers and Miners*, by T. W. J. Connolly, Vol. II., p. 492.

Each bar of brass, and of iron, was 10 feet $1\frac{1}{2}$ inches long, $\frac{1}{2}$ inch broad and $1\frac{1}{2}$ inches deep, and the bars were placed $1\frac{1}{8}$ inch apart, and firmly connected at their centres. The metal tongues connecting the ends were about 6 inches long, and on a silver pin at the extremity of each, was marked the compensation point. With the figures given, it will be seen that the compensation point was about 3 inches outside the iron bar.

There were six of these compound bars; in the field they were placed on trestles, with elaborate arrangements for aligning and levelling. The bars were placed end to end, but not touching, and the distances between the compensation points were fixed by two microscopes attached to the cases which held the bars; the two microscopes lying parallel to each other and connected together in such a manner that the outer foci of their object glasses were compensated points exactly six inches apart.

The authoritative account of this apparatus, and of the measurement of Lough Foyle Base, and of the many experiments necessary to determine the expansions of the metals and the positions of the compensation points, and of the calculations for the definitive value of the length of the base itself, will be found in *An account of the Measurement of the Lough Foyle Base*, by Captain William Yolland, R.E. This account was not published until 1847, about 20 years after the measurement was made, and just at the time that Colby was retiring from the Survey. The lateness of the publication of this account is evidence of the reluctance which was, apparently, always felt by Colby to publish anything connected with the work; and this reluctance may have been partly due to his remembrance of the refusal of the Board of Ordnance in Mudge's time, in 1811, to publish any more reports of the work of the Trigonometrical Survey.

The Measurement.—The officers employed upon the measurement of the Lough Foyle Base were Lt.-Col. Colby, Captain Pringle, and Lieutenants Drummond, Henderson, Murphy and Mould, all of the Royal Engineers. About half the soldiers working under them were Artillerymen, and about half Sappers and Miners; the largest number employed at any one time (in October, 1827) consisting of 27 Artillerymen, 25 Sappers and three civilian labourers.

The site selected by Colby was a stretch of ground along the eastern shore of Lough Foyle, at an average height of 18 feet above mean sea level. The chief difficulty to be contended with was the crossing of the River Roe at about the middle of the line. The length was nearly eight miles. Drummond writes on the 24th June, 1827:—"The encampment is by the side of Mr. Gage's park wall, near the Roe."

The actual measurement began on the 6th September, 1827;

this was continued until the 25th October. Work was resumed on the 7th July, 1828; continued until the 25th of the same month, when it was suspended to avoid damage to the crops. It was again resumed on the 13th September and completed on the 20th November, 1828. The number of days spent in measuring was 95, and the average daily progress was about 460 feet. Sir John Herschel and Babbage visited the work, and the former made a sketch showing the method of measurement.

The Standards of Length.—Two new standard wrought iron bars were made by Messrs. Troughton and Simms in 1826-27. These bars still exist, and are 10 feet long between the measuring dots. Each bar is 1.45 inches broad and 2.5 inches deep. The distance of 10 feet was marked when each bar was at a temperature of 62° F. These bars are known as O_1 and O_2 ; O_1 was sent to Lough Foyle to enable comparisons to be made with it; and O_2 was retained in the Tower of London, in case any accident might happen to the first bar.

Yolland quotes no fewer than eleven other bars and scales which, up to 1846, had been used as standards in Great Britain, or had been compared by the Ordnance Survey. These include Bird's Standard Yard of 1760, which was destroyed in the fire which consumed the Houses of Parliament; the Indian 10 feet iron standard bar B, the Cape 10 feet iron standard bar B, Roy's brass scale, Ramsden's 20 feet triangular iron bar, Simms' 10 feet iron bar, and others.

Accuracy of the Base.—The length of the Lough Foyle Base, in terms of feet of O_1 , was found to be 41640.8873 feet. This base has never been re-measured, so that there is no direct test of its accuracy. But an indirect test exists. The net-work of the Principal Triangulation connects the Lough Foyle Base with the Salisbury Plain Base, which was measured in 1849 with the same apparatus. If we assume that the latter base is errorless, the length of the former base, calculated through the triangulation, differs from the measured length by 5 inches. Clarke, in his reduction of 1858, took the errors of these bases to be inversely as the square roots of their lengths, and the discrepancy of the measured, as compared with the calculated value, of the Lough Foyle Base is, then, about $2\frac{1}{2}$ inches.

On the lengths of these two admirable bases, given in feet of the bar O_1 , depend all Ordnance Survey measurements to this day.

Some Letters about the Base.—Capt. Pringle to Colby, Trig. Survey Camp, Magilligan, 13th September, 1827:—

"The severe gale which we experienced on Sunday morning and which is represented by the residents on the plain as what may be frequently

expected to occur in the course of the Autumn, has convinced me and the Officers employed on this duty of the expediency, or rather, necessity of being enabled to augment the night guard. . . The guard cannot be trusted to the civil labourers whom we can hire for day work. . . . The Artillerymen here have conducted themselves with the greatest regularity and are particularly fit for the duties required."

In another letter he asks for a corporal or sergeant and 8 or 12 Artillerymen.

"For as the season advances storms will be frequent." "Drummond and Murphy were out at six this morning, Henderson and I relieved them at eight, but still only two moves . . . 12 or 15 Artillerymen would be only so many shillings a day."

Magilligan Camp, 3rd July, 1828 :—

"The Detachment of Artillery, 13 men, have just arrived. . . . Corporal Young and the other men who were with us last year have not arrived. Pray order them without delay . . . otherwise we shall have all the annoyance and delays of teaching to repeat. Lieut. Murphy we have heard nothing of, and are anxious about him. Lieut. Henderson writes he is to be here on Sunday, and Capt. Waters that Lieut. Mould is to come when he has finished his station. Lieut. Drummond has finished all the comparisons and made the adjustments, and has also set up marks on the line, so we are quite ready to commence when two more Officers join. . . You took . . . a memorandum to order another Smith from the party in the hills, which I hope you have done, as we shall have a great deal of Smith's work.

"We have been examining the Roe and considering the easiest mode to measure across it. Driving piles appears on the whole the best, so I shall order piles, etc., from Derry. We are experimenting with a frame filled with sand bags, or stones." . . .

On the 16th July, 1828 :—

"We now hope to pass the Roe the end of this week. We have been pushing very hard to do so, commencing at 3 a.m., as the tides will answer best—being high water at mid-day. . . There is only about a quarter mile beyond the Roe until we come to continued crops. . . I have been too busy to think of the Geological Memoranda."

26th July, 1828 :—

"Lieuts. Henderson and Drummond have been advocating the policy of buying the Crops—this season is, no doubt, the most advantageous for measuring, morning and evening. But I think the appearance of what would be judged unnecessary damage, is much against it. . . . The men are employed now in drawing up the piles in the Roe. . . The party of Artillery . . . will march for Charlemont on Tuesday. . . P.S.—Sergeant Sim has come to tell me that the men would rather remain here even without pay than go to Charlemont and [I] propose to retain them on half-pay /6, if we commence in six weeks."

In a letter to the Board of Ordnance written in February, 1828, with reference to the possible employment of Captain Pringle on

temporary duty in Canada, Colby asks that he may not "be deprived of the services of that excellent officer" beyond the period which might be necessary.

From Lieut. Hastings Murphy, R.E., to Colby, Magilligan Camp, 18th July, 1828 :—

"I left my calculations, etc., with Portlock. . . Portlock was very well and in good spirits, but had seen nothing to the South, except Ardan Erin. . . I remained with them about four hours on Friday and pushed on to Enniskillen, and here next night. We are getting on famously, having last night reached the Roe; if this day were not so very windy we should be across this evening. We have been at work about 16 hours a day."

Murphy to Colby, Ballykelly Camp, 12th November, 1828 :—

"I hasten to reply to your kind enquiries after our friend Drummond. I have just been to see him in his comfortable quarters at the Glebe, and am happy to say he is doing very well, having sat up to-day for three hours and eaten part of a chicken. . . Certainly he gains strength every hour compared with the extreme state of debility to which he had been reduced by fever, bleeding (30 ounces at once), medicines, etc., etc. . . Dr. Dice, of Newtown, has been his physician . . and bled him very freely at first, and said it saved him from a bad typhus or rheumatic fever or both."

The writer of these two letters, Lieut. Murphy, did much excellent work on the Ordnance Survey, not only in the measurement of the Lough Foyle Base, but also in the observation of angles on Divis, and at other stations, and in the comparison of standards. He left the Survey in 1834 to accompany Colonel Chesney's expedition, which was to examine into the possibility of establishing communication with India by way of the Euphrates. He died at Bussora in July of that year.

IX. PROGRESS OF THE SURVEY OF IRELAND FROM 1826 TO 1839.

PORTLOCK, REID, LARCOM, O'DONOVAN.

Colby's System.—Colby often refers in his letters to his "system" of surveying, and as this system is the origin of the distinctive methods of the Ordnance Survey, it will be as well to describe it briefly. The main principle of Colby's system was that of division of labour; the all-round subordinate was not wanted in this system. Each man had a definite job to do and was kept at that. The surveyor who carried out the chaining did not plot his work; the plotting was given to other men. The man who plotted the main lines of the survey did not plot the detail. Afterwards, by an extension of the system, the surveyor who examined the work on the ground and inserted names and descriptions had nothing to do with the drawing or tracing. In the trigonometrical branch, in later years, the observers never computed their observations, but worked quite blindly as to the results of their work. There is much to be said for such a system; each man becomes very expert at his own particular speciality. It sounds, perhaps, a little dull for the surveyors; and, indeed, some men spent their working lives in doing the same thing over and over again. But it is less dull than it sounds, and if a surveyor in the field became incapacitated by illness, or from other causes, he could be brought into the office and trained up in another routine. The method is well suited to the large-scale survey of a civilized country; it would be quite unsuited to the topographical surveying of a tropical dependency.

Some copies have come down to us of the *Instructions for the Interior Survey of Ireland*, a small pamphlet of some 30 pages, "lithographed at the Ordnance Survey Office, Phoenix Park, Dublin," in 1827. The *Instructions* begin with the statement that, "The Interior Survey of Ireland is to be performed on a Scale of Six Inches to one English Mile; and the Plans are to be drawn with all the Accuracy and Minuteness of detail which that Scale admits." The whole work was, of course, based on the Great Triangulation, which depended, after November, 1828, on the length of the Lough Foyle Base. A certain number of points were intersected from the principal stations, and we may suppose that the officers who were responsible for the "interior survey" were given the bearings and distances of points some ten miles, or so, apart. "The subsidiary Triangulation for determining the Interior Points for regulating the Survey being to be performed

by the District Officers, who will combine with that operation the determination of a good series of altitudes." In 1833 all trigonometrical work was placed under a special division. The detail was surveyed almost entirely by chaining; traversing was not generally allowed. From trig.-point to trig.-point the chain was dragged; the interior of the triangles being also split up by chained lines. Every boundary line was chained and all important features. Traversing, though not absolutely forbidden, was discouraged. Even in the towns the detail survey was carried out by simple chaining. An exception appears to have been made in the case of the survey of winding streams in deep valleys, and, generally, traverses became allowable in uncultivated and wooded districts and in the mountains. But, for towns, the prohibition appears to have remained in force until 1897; and much ingenuity used to be displayed by the surveyors in carrying out the survey of close towns by right lines.

"The plotting is to be performed on sheets capable of containing at least ten or twelve square miles. . . . The Trigonometrical Points are to be pricked off on the paper before the plot is commenced. . . . The Plans are to be co-extensive with the Parishes, each Plan containing a single Parish, except in cases where Parishes are so small that two or more may conveniently be put together. . . ."

Since the areas of Baronies and Parishes were required as well as those of the Townlands, instructions were given that the chain lines should be laid out chiefly with reference to the larger divisions. Hence long lines were not uncommon; in the example given in the pamphlet there is a chain line over three miles long, and many were longer.

The areas were calculated, and not measured from the plan as they are in modern Ordnance Survey practice. A later article reads, "In the first article of these Instructions it is directed that the survey shall be performed on a scale of six inches to a mile and with all the accuracy of detail which that scale admits. It is not, however, intended to put in the Fields generally, but with this exception everything attached to the ground is to be inserted on the Plans."

In accordance with the instructions of the Select Committee, the early six inch sheets did not show the field boundaries, except where they coincided with the townland or other administrative boundaries. Larcom, writing in later years, says:

"At this time (1843) another circumstance had arisen; the early Northern Counties had not been surveyed with the degree of detail which had been attained in the South, when the men and officers had attained greater experience and skill. The tenement valuation, now introduced, for the Poor Law, required this detail accordingly on the Memorials of the Northern Counties; the Government allowed the Maps of them to be revised."

"The persons employed on the survey" were to endeavour to obtain the correct orthography of the names of places by diligently consulting the best authorities within their reach; the various modes of spelling a name were to be given and the authorities quoted.

"The boundaries of the several legal and ecclesiastical divisions of Ireland" were to be pointed out to the officers, "by persons authorized and directed to shew them by His Excellency the Lord Lieutenant: and the District Officer is to send to notify the times and places" where these persons' services were required. Precise instructions are given that no boundary is to be surveyed unless it is completely marked and pointed out on the ground.

The Committee of Enquiry of 1828.—In its early days the Ordnance Survey of Ireland was by no means universally popular. Local surveyors naturally felt that their bread and butter was being taken away from them. There were those who looked upon the whole undertaking as a piece of State interference. It is probable also that the Boundary Department would have liked to carry out the work itself; certainly the two departments did not get on well together. And many looked doubtfully upon the employment of soldiers. Captain Waters writes to Colby from Londonderry, on 28th March, 1828:—

"I do believe that the greater Part of the Civil Engineers of Ireland are hostile to Our having the Survey; that from the intercourse they have with the Gentlemen of the Country an Opportunity is afforded of poisoning their minds as to its accuracy, and that the idea of employing Soldiers to execute what they alone imagined themselves qualified to undertake is a disparagement which they cannot well brook."

Then Colby introduced a new system, and even some of his officers failed to give him the support which he needed, and advocated systems of their own. It was inevitable that complaints should arise from many different quarters. Misrepresentations appeared in the press. Accusations of extravagance and inefficiency were made to the Board of Ordnance. As early as February, 1826, only a few months after the survey was started, Sir Henry Hardinge wrote from the Board of Ordnance to Colby:—

"I have received a letter in which it is stated that 'the whole of the Survey in Ireland has failed.' I do not attach, of course, much importance to this Statement, but I beg to remind you of my recent request to be furnished with an account of the progress made in the Survey. . ."

Colby was indignant at the rumours, and wrote to the Board of Ordnance. Hardinge gave Colby some very sensible advice in a letter dated 22nd April (probably 1828). He says:—

"I consider that every Dept^t. in employing its officers ought to give them its support, most especially in the case of rumours and reports not proved. But, on the other hand, when the rumours

admit of clear demonstration, the Person attacked ought to be most forward in courting enquiry and challenging proof. In short, the doubtful must be satisfied, and where the *exact sciences* are the subject of dispute, the only way of dispelling prejudice and unfairness is to come to the proof. Now the rumour that the Survey of Ireland is not properly conducted gains ground—persons high in office have received impressions that yr. *system* is wrong and liable to error. This is a point that I would grapple with. Officers of your own Corps as well as Civil Surveyors give it against you. This surely is capable of Demonstration. Secondly, it is stated that Errors to a large extent do exist owing to this Defective System of calculation (not to the Boundaries), and again, I say, call for one, two, or more instances to be specified—calculate the contents in different ways (the boundaries remaining the same), and ascertain whether the attack be just or unjust. . . If you are supine or passive, you will in a short time longer have such a mass of prejudice to contend with that yr. position will be uncomfortable : by challenging and seeking Enquiry, and making it yr. own act, you get rid of that awkwardness."

The upshot was that, on the 14th July, 1828, the Board of Ordnance wrote this letter to Colby :—

SIR,—In consequence of the continued reports of which you are aware respecting the Survey in Ireland, the Master General has given directions to Major-General Sir James Carmichael Smyth, assisted by Lieut.-Colonel Sir George Hoste, to proceed there immediately, for the purpose of enquiring into the state and progress of the Survey, with instructions to ascertain whether any better mode can be devised for the future conduct of it.

And I am commanded by His Lordship, in acquainting you therewith, to desire that you will attend to such communications and directions as you may receive from Sir James Carmichael Smyth in fulfilment of the Mission with which he is charged. I have the honour, etc.—
DOWNES.

Sir James Carmichael Smyth was a distinguished Royal Engineer Officer, who was born in 1779, and was thus 49 years old when this duty was thrust upon him. He had served with Sir John Moore at Corunna, and had been on Wellington's staff at Quatre Bras and Waterloo. He became Governor of Bahamas, and, later, of British Guiana, and died at Demerara in 1838. He was a good soldier, capable and popular, but it was not likely that he could teach Colby anything about surveying, though, being an R.E. officer, he probably thought that he could.

Portlock, always a friend, writes to Colby on 26th July :—

"I should not intrude upon you at this moment did I not conceive that the expression of undiminished attachment and fidelity to your cause cannot be unwelcome. Alarming as this crisis is, I do not despond. Your cause must triumph over the efforts of a despicable cabal. All I trust is that you will not allow such petty and repeated vexations to tempt you to resign. That is, I doubt not, their hope. . ."

Well, the Committee went over to Ireland and made their report, in which the principal recommendations were that the areas should be measured from plots on the 12-inch scale and that a system of traversing round the boundaries should be adopted. Colby resented the method of enquiry by which the Committee usually examined his officers, as it were secretly, and not in his presence. He writes to Sir James Smyth on the 3rd September, 1828, as follows:—

“Instructions as to the mode of carrying on the Survey coming with the Master General’s authority relieve me from a heavy responsibility, and must, therefore, be highly acceptable. But in those you read privately to me yesterday, there is no direction to provide the additional number of theodolites required for traversing boundaries, and the checks which I am to direct to ensure the accuracy of that mode of surveying were not enumerated. In the direction to compute the areas of the townlands from paper solely, the number of independent plots from which the computation is to be made and the scale of the content plot . . . were not mentioned. The Boundary remark Books are not directed to be preserved or sent to Mountjoy, and thus the check on the boundary department is done away without any apparent saving of time or money. . . .”

Portlock says that during the progress of the enquiry he was camped upon Cuilcagh, engaged upon the triangulation. Cuilcagh is a mountain 2,180 ft. high, 12 miles S.W. of Enniskillen. It commands “a vast number of churches and other points connected with the district triangulation, and thereby assisting to furnish bases for the surveys of about 20 counties.” Colby took the two commissioners up this mountain in order that they might see for themselves the trigonometrical methods in use and might question Portlock. The latter writes:—

“If, as they certainly did, they toiled, panted, and blowed upon their ascent, envying, no doubt, the elastic and never-faltering step of their more experienced comrade [Colby], they appeared, on arriving at the summit, to forget their fatigue and to be repaid for their exertions. . . Both Sir James . . . and Lieut.-Colonel Hoste expressed the highest admiration of what they saw : but alas ! whilst they praised the executive officer, they overlooked or failed to appreciate the merit of the man who had planned the work which the other executed, and thus fell into that error which has been only too common in estimating the services and talents of General Colby.”

Colby’s views on the report are expressed in a letter to an unknown correspondent :—

“You are well aware of the vehement prejudice which exists against me at the present moment : and that any representation coming from me for the purpose of relieving the Irish Survey from the deadly wound it has received from Sir James Smyth, would merely be treated as an emanation from my wishes to have my own way. . . . To a superficial observer the changes effected by the Master General’s orders may appear

only a sacrifice of a certain portion of accuracy and completeness of information to an increase of celerity. But where upwards of 700 persons have been cautiously trained to a system, with a view to give the division of labour its most beneficial effect, the slightest change, which would pass almost unnoticed by a single executive officer, operates as a powerful check on the aggregate."

In another letter from Portlock to Colby of the 24th October, we find:—

"Larcom has told me the result of the investigation, and whilst I deeply feel for those parts which must be unpleasant to you, I see in the whole enough to support you against the whole cabal. They have not dared to impugn the System, they have given an admirable testimony to its merits."

But Colby was by no means happy about the business. In January, 1829, he says that the Survey

"is languishing under the baneful effects of the late investigation. . . The two main difficulties to be overcome in the Irish Survey were: the vague and careless manner in which the Boundaries were laid out by the Boundary Department under the Irish Government, and the vehement desire of the Engineers to make apparent progress without due regard to the character and quality of the work. My task in compelling all parties to do their duty was most irksome and invidious."

He goes on to say that he always felt sure of support as long as the Duke of Wellington remained Master General. And he points out that the new instructions have had a marked effect in reducing output.

But things settled down. The order about traversing seems to have been withdrawn; and, as to measuring areas on paper, that is Ordnance Survey practice to this day, though the 12-inch scale is not used. In November, 1829, Sir Henry Hardinge writes to Colby, "I was happy to hear you are getting on prosperously with the Irish Survey." And there we can leave the Committee of Enquiry, which did less harm than might have been expected, but left behind it in the Ordnance Survey a departmental dislike of traversing, as of some slack and irregular method, which no decent surveyor would make use of if he could possibly employ another.

The Triangulation of Ireland.—There are thirty-four stations in the great triangulation of Ireland, rather more than one per county; they are all hill stations and the height of most of them is considerable. The highest is Brandon, in County Kerry, which is 3,119 feet above the sea. Next in height is Galtimore, 3,007 feet. Then there are Baurtregaum, 2,788 feet; Slieve Donard, the same height; Mount Leinster, 2,602; Knockmealdown, 2,601; Knockanaffrin, 2,470; Kippure, 2,465, and so on. The average height of these 34 hill stations being about 1,850 feet above sea level.

Two rays, Slieve Donard-Cuilcagh-Tawnaghmore, are sufficient to cross Ireland from the Irish Sea to the Atlantic. Three rays, Slieve Snaght-Cuilcagh-Keeper-Baurtregaum, cover the length of Ireland from the north to the south-west. The longest ray in Ireland is that from Cuilcagh to Keeper, which is 102 miles long; the next longest is that from Keeper to Nephin, which is over 98 miles long. From Cuilcagh about half of the country—that is, the centre and north—can be seen; and from Keeper the centre and the greater part of the south. So that from these two stations almost the whole of Ireland is visible. In the *Account of the Principal Triangulation* it is stated that the station of Slieve League, a mountain nearly 2,000-ft. high, in the extreme south-west of Donegal, was marked by a pile of stones, which “indicates the spot where the great instrument was once in position on the wildest headland probably in Great Britain or Ireland.”

Practically all the angles of this triangulation were observed by Captain (afterwards Major-General) J. E. Portlock, R.E., with the 3-ft. theodolite B.O. (Board of Ordnance); the instrument, that is, that was made to the order of the Honourable Board and was first used in 1791. All this work was finished by Portlock by 1832, and the triangulation was then looked upon as completed, though, in the forties, two stations were revisited and three more were added to Portlock's. The probable error of a single angle was about two seconds.

And here, perhaps, a note as to what purpose the triangulation of Ireland was meant to serve may not be out of place. It was never seriously attempted to use the work in the determination of the figure of the Earth. The best proof of this is that, in the whole of Ireland only four latitudes were observed, and these not until 1843. The object of the triangulation of Ireland was the purely practical one of providing an accurate basis for the 6-inch maps.

The County Meridians.—There is a technical matter with regard to which we can say definitely that our predecessors were unnecessarily strict. In Ireland it was arranged that each series of 6-inch sheets for any one county should be plotted, independently of those of other counties, on a meridian chosen for that county. The method of plotting, that is, “the projection,” was the following:—A central meridian was selected and this was represented on paper as a straight line; some point on this meridian was chosen as the origin. Then the position of any other point was fixed by the length of the great circle on the earth's surface, from the point in question, perpendicular to the chosen meridian; and the other co-ordinate was the distance along the meridian from the foot of the perpendicular to the origin. The great circles

mentioned were plotted as straight lines at right angles to the central meridian. In this projection, which is an excellent one for the purpose, there is very little error in an east-west direction. But the error in a north-south direction increases approximately as the square of the distance from the central meridian, owing to the fact that, in nature, the great circles converge, whilst on paper they are plotted as parallel straight lines.

Our predecessors were well aware of the existence of this error, but seem to have been unnecessarily afraid of it. By limiting the area plotted to a single county they certainly reduced the resulting error to an altogether negligible quantity; but they might have been much bolder. The multiplication of meridians has the great disadvantage that there is discontinuity at every county boundary. The maps were, therefore, published county by county, and there is no detail shown beyond the county boundary, so that there is much waste paper.

If we take the meridian 8° W as a central meridian for the whole of Ireland, and measure from this meridian, we shall find that the greatest extension of land eastward is less than 105 miles, and the greatest extension westward is less than 115 miles. If the whole of Ireland were plotted on this one meridian, the greatest error of scale due to the projection would be less than 1 : 2300 ; and this error, by a device which need not be described here, could be reduced to less than 1 : 4600, and in computing areas this small error could be allowed for. The six-inch maps of Ireland might, therefore, have been plotted on one single meridian, instead of on 32 meridians—one for each county ; and time, money, and inconvenience might have been saved. But to say this is not to undervalue that remarkable work, Colby's six-inch survey of Ireland, but only to point out that, in one particular, it suffered from what appears to us, nowadays, as an unnecessary scrupulosity.

Progress of the Six-inch Map, 1829-1839.—Although the Smyth enquiry caused some delay, the field work of the six-inch map seems to have recovered in the course of a few years ; but the rate of execution was not as rapid as Colby had originally hoped for. However, by the end of 1839, the work was very well advanced, and this was its state :—About three-quarters of Ireland, from the extreme north down to a line including Galway, King's County, Queen's County, Carlow and Wicklow, had been surveyed in the field. The six-inch sheets of the northern half of the country had been engraved and published. Only two counties had not been taken up, namely, Cork and Kerry. It would not now be many years before the whole undertaking was finished.

The maps were beautifully engraved ; indeed, the engraving is so fine that it is difficult to reproduce it. During the greater



part of this period the headquarter office at Mountjoy was under the charge of Lieut. T. Larcom, an officer of exceptional capacity. The engravers were: McCoy, Sandys, Macaulay, Duncan, Fraser, Chisholm, Aikman, Oldham, Darling, Sergeant West and Corporal Keville. The first county to be engraved, Londonderry, with an area of over five hundred thousand acres, was finished in 1832; and, as we have seen, the sheets of this county were submitted by Colby to King William IV, in May, 1833.

These early six-inch sheets show no contours; occasional heights are marked in feet, reckoned from low water; but the Irish datum was not exactly fixed until 1837. The various county, barony, parish and townland boundaries are very clearly shown, as, of course, was necessary, for the determination of these boundaries was the original main purpose of the map. The sheets have a very characteristic appearance, not only from the fineness of the engraving, but from the abrupt endings of the minor roads, and the number of circular, pre-historic "forts" which are scattered over the surface of the countryside. These interesting relics of the past average about fifty yards in diameter, and one may say that there is a "fort" in every two or three square miles. There are probably at least ten thousand of them in Ireland.

Portlock.—Nearly all the observations on the mountain tops of Ireland, for the Great Triangulation of that country, were taken by Portlock. His career is an interesting one to study, for it combines, to a remarkable degree, soldiering, surveying and more abstract science. He was born at Gosport in 1794, and was the son of Captain N. Portlock, R.N., who was one of the loyal colonists of America. The elder Portlock had entered the Navy as a midshipman under Captain Cook and was with him at his death. The son, Joseph Ellison Portlock, the subject of this notice, was educated at Tiverton and thence went to the Royal Military Academy and obtained his commission in 1813. The next year he took part in the siege of Fort Erie, in Canada, and for the greater part of the time was the only engineer officer in the trenches.

"He constructed the lines and *tête de pont* of Chippewa, at which Lt.-General Sir Gordon Drummond made his successful stand and saved Upper Canada. For his services on this occasion Portlock was thanked in general orders. He was afterwards employed on numerous exploratory expeditions. Portlock Harbour in Lake Huron was named by Sir Gordon Drummond in memory of Portlock's services."*

In 1824 he was posted to the Ordnance Survey and became Colby's confidential friend and companion, and in 1825 he commenced his work on the triangulation of Ireland, by taking part in the observations on Divis. In 1826 we find him on the very

* *Dictionary of National Biography.*

expo ed station of Slieve Donard, in County Down ; and in 1828 he remained in camp, on the top of Slieve League, in County Donegal, 2,000 feet above the sea, until the middle of January. The Great Triangulation was practically completed by him in 1832. He then directed the operations for the minor triangulation and organised an elaborate system of vertical observations for altitude. In the same year, 1832, he undertook a survey of geology and productive economy for Ireland. He had many difficulties to contend with ; as he said himself, " Geology was permitted not commanded." In 1837, he formed, under Colby, a geological and statistical office as a branch of the Survey. It had been intended to publish elaborate memoirs of all the counties, but after the publication of one volume of the series, this was stopped on financial grounds. The Geological Survey was, later, resumed.

Portlock's memoir of Londonderry was the commencement of the Geological Survey of Ireland.

Sir Roderick Murchison, then President of the Royal Geographical Society, speaks thus of Portlock in his address of May, 1864 :—

" This volume of Portlock's on the geology of Londonderry is a perfect model for fidelity of observation and minute attention to phenomena. To the quickness of his eye, and his resolution to surmount difficulties, we also owe the first detection in Ireland (Tyrone) of those trilobites and other organic remains which enabled him to identify these rocks with the Silurian rocks of England and Wales very shortly after my first classification of these older palæozoic rocks. . . . He was, in truth, a geologist quite after my own heart ; for in him an acquaintance with rocks, minerals, and fossils was united with the full knowledge and feeling of a true physical philosopher."

Murchison then quotes Sir Thomas Larcom, who was Portlock's friend and contemporary on the survey :—

" The characteristics which shone forth in Portlock during his well-spent life, whether as a soldier, a geographer, or a geologist, were undaunted courage in facing difficulties, Spartan endurance and invincible perseverance in overcoming them. Endowed, when in the zenith of his career, with a frame and nerves of iron, he exhibited such a vast power of continuous labour that he achieved every object he had in view ; whilst great ability and a pure love of knowledge were in him guided and governed by the highest sense of honour and moral rectitude."

In 1843 Portlock's work on the Survey of Ireland came to an end. It appears that about this time Colby and Portlock no longer saw eye to eye, and it must be admitted by the truthful historian that Colby had rather a knack of quarrelling with his officers ; at least, that was the case with Drummond, Reid and Portlock, all very able men. But, however that may be, in 1843 Portlock, who was then 49, was ordered to Corfu. In 1849, he was C.R.E. at Cork ; in 1851, he was appointed Inspector of Studies at the



MAJOR-GENERAL J. E. PORTLOCK, R.E.,
LL.D., F.R.S., F.G.S., &c.
1794-1864.

*Reproduced, by permission, from a photograph in possession
of the Geological Society of London.*

R.M.A. In 1856 he was C.R.E. at Dover, and in 1857 he was appointed a Member of the Council of Military Education. He retired in that year, but retained his post till 1862.

Whilst he was at Woolwich he wrote the *Memoir of the late Major-General Colby*. Colby died in October, 1852; the first instalment of the memoir appeared in the *R.E. Professional Papers* for 1853, and the memoir was continued in 1855 and '56. This account is more than a biography, and contains a good deal of technical information in addition; but it is, perhaps, most useful now in its main purpose of throwing light upon the life and character of Colby. If it were printed in large print it would make quite a substantial book, for it contains some 90,000 words. Portlock's own character comes out very well in this memoir, which was written in pious memory of his old chief, in spite of the fact that Portlock did not feel that, in later years, he had been very well treated by him. He says at the very end of the memoir, in admirable words:—

"In my early connection with the Irish Survey, I was his chosen assistant and confidential adviser. . . . In the later period of my connection he was estranged in feeling towards me; but as I now look back on the past from a more distant point of view, I cannot doubt that there were faults on both sides . . . and feeling that the early kindnesses and services I received from him far outweigh the later harshness. . . I am proud to have had the opportunity of recording my respect for the memory of a man towards whom, when living, I always felt and expressed affection."

From 1856 to 1858 Portlock was President of the Geological Society of London.

He died at his home near Dublin in 1864, aged 70.

There is a curious letter from Portlock to Larcom, who preserved it amongst a collection of letters now bound together and kept at the Ordnance Survey Office. Larcom was six or seven years younger than Portlock, who writes in 1826 from camp in the north of Ireland, evidently suffering from ague:—

"My dear Youth, I am, of course, better to-day, and must for a time live on hope. I send you Yule's Diagram of Points. [Then follow some technical instructions.] Take care of yourself. I drink hard for security. Not that I recommend Intemperance. Sim ought to have known better than to drive the Pegs too low. Ever, my dear Youth, Your miserable J. E. PORTLOCK."

On October 12th, 1826, he writes to Larcom from Sleibh Donard:

"My dear young Gentleman,—On the opposite whole margin you have the necessary data for Holyhead. Those for Snowdon I shall despatch To-morrow or next day addressed to you at Carnarvon. . . I hope to be off myself in the course of next week. Drummond has made good his footing: he looks very unwell and would have acted more wisely had he remained below."

On the opposite page are instructions for setting the instrument at Holyhead station so as to intersect the light on Sleibh Donard.

There is a bundle of letters from Portlock to Colby, written between 1825 and 1829, almost entirely about the trigonometrical observations. From Newtown, Limavaddy, November 18th, 1825, Night :—

"Wind is now so constant either from one quarter or another that it is impossible to observe without a Tent. . . November 19th, My Tent still standing though almost every Cord has been broken and repaired."

Knocklayd (1,677-ft.), in Antrim, July 15th, 1827 :—

"There is as yet no improvement in the Weather as regards observations. Morning after Morning I have had the mortification of seeing the Horizon shrouded in mist or fog and the Sun rising high before he could break through. . . My only dread is that, deceived by the lovely weather, you may feel a difficulty in fully estimating the extent of haze which surrounds this Hill."

From the same station, August 17th :—

"Yesterday and this morning I have had several takes of Ben Lomond, most, indeed, hazy, but two or three very fair and the whole giving a mean difference only 2" from what it ought to be according to the former angles. Cairnsmuir has not again shown itself sufficiently clear."

From Sawel (2,228-ft.) in County Derry, September 18th, 1827 :—

"I avail myself of some Clouds, which, I hope, will be passing, to write you a few hasty lines. You certainly carried with you the observing weather, as nothing important has been done since. Friday and Saturday, constant Fog. Sunday baffling clouds, a few Donegal Points in the Afternoon. . ."

Slieve Snacht (2,011-ft.), in County Donegal, October 4th, 1827 :—

"I am told that the Weather is free below, and I rejoice for all your sakes that it is so. Here we have an interminable Fog. The Night is likely to be wild, but we are so secured by huge Stone Traverses that we have nothing to fear. . ."

Cuilcagh (2,180-ft.), in Fermanagh and Cavan, June 25th, 1828 :—

"On Friday last we met with a singular accident. It was a stormy, unsettled day, but one, during the intervals of Showers, very favourable for churches, and I was, therefore, fixed to the Observatory. A violent hailstorm came on, and I was just stooping to take up one of the Microscope leaps, my head being near the open side of the Observatory, when I received a smart Slap (as it were) on the top of my head from a passing flash of Lightning, and raising my head, somewhat surprized, I just saw Gunner Phibbs who stood in front (being watch) roll round and tumble to the ground. He rose again, but instantly fell and remained in a kind of torpor, breathing heavily, for about twenty minutes, when he began to recover. He seemed stupefied and quite unconscious of the true cause, feeling as if intoxicated and fancying that he had slept on his Post. As soon as he could walk I sent him down the Hill, when he was bled."

Writing from camp at Croghan, County Wicklow, on 3rd January, 1829, Portlock says :—

"As to Health, I heartily thank you for your kind concern about us all. . . I have little apprehension as to myself, that Bane a Fire not being admitted to my Quarters. The Men, too, are in excellent Health. . ."

Kippure (2,465-ft.), in County Wicklow, July 5th, 1829 :—

"Yesterday Afternoon, at 5 p.m. I for the first time saw the Precelly Heliostat and took it twice with Lugnaquilla and Bray Head, the only convenient referring Points in sight. Clouds then cut it off, but . . we shall doubtless see it often again. . ."

This ray from Kippure across the Irish Sea to Precelly, in Pembrokeshire, is over 107 miles in length.

The letters are all much in the same strain. They naturally dwell a great deal on the weather. But Portlock evidently enjoyed the work, in spite of fog and storm, on the tops of the Irish hills.

His was an interesting life. Early in his career campaigning and exploring in Canada ; then carrying out, almost single-handed, the great triangulation of Ireland ; then soldiering in a more humdrum way in Corfu, Cork, Dover and Woolwich ; the founder of the Geological Survey of Ireland ; President of the Geological Society. Larcom uses the right word when he speaks of Portlock's well-spent life. In later years his name has been almost forgotten on the Ordnance Survey. It is hoped that the foregoing brief account of his career may serve to revive the memory of this fine old officer, who, indeed, deserves to be remembered, with Roy and Mudge, with Colby, Drummond and Larcom.

Sir William Reid.—When the Survey was begun in Ireland, in 1825, Colby placed Major W. Reid in charge of the Mountjoy office, and, in effect, in general charge of the operations in Ireland whenever Colby was called to London, as not infrequently happened. Reid was an officer of outstanding ability, who had served with great distinction in the Peninsula. But he had his own ideas as to how the Survey should be conducted, and as these differed from Colby's, especially at the time of the Enquiry of 1828, he left the Survey at the end of that year. So far as the Survey is concerned, we do not again come across him until 1850, when he did the Department a very good turn by recommending Lt. Alexr. Ross Clarke for employment on it.

Reid became, successively, Governor of Bermuda and Barbados, then Chairman of the Executive Committee of the Great Exhibition of 1851, and finally Governor of Malta. He died in 1858, aged about 67. He was the author of Reid's *Law of Storms*, and was a Fellow of the Royal Society.

Sir Thomas Larcom.—Good men seem to have been common in those days ; Colby found to succeed Reid an officer who was in every way fitted for the post, and who, in after years, took

a large part in shaping the history of Ireland. Thomas Aiskew Larcom was born in 1801, and after a brilliant course at the R.M. Academy, was commissioned as 2nd Lieutenant in the R.E. in 1820. He was posted to the Ordnance Survey in 1824. When Reid left, Larcom took his place at Mountjoy.

"Here he soon had the work in his own hands. He organised the large body of civilians and soldiers required for the multifarious operations of compiling, engraving and publishing the county maps of Ireland, the beauty of which has never been exceeded; adopted the electrotypes process, and introduced the system of contouring. Mountjoy became a centre of scientific education, and the resort of scientific men."*

During his 18 years at Mountjoy he served on many committees and commissions, and made use of every opportunity to increase his knowledge of Ireland. He took immense interest in all that concerned Ireland—history, archæology, language, literature, topography, place-names, folk-lore and what not. He acquired a wonderful fund of information about the country and people, which was afterwards to serve him in good stead.

In 1846, when the original six-inch survey was completed, Larcom left the Survey and became a commissioner of public works. In the Great Famine he was appointed chief director of relief works. In 1853 he was appointed Under-Secretary for Ireland, and he remained in this post until 1868. It is a testimony to Colby's good judgment in the selection of his officers that two of them, Drummond and Larcom, became the virtual rulers of Ireland. "Larcom, adopting the policy of his friend Drummond, undertook to govern all parties alike with even-handed justice, to remove abuses and prevent disorder."

"If he had been Viceroy for those sixteen years, he could not have been more entirely identified during that time with the government of Ireland. Each of those great officers. . . Whigs and Tories alike, vied with each other in their recognition of his services. Men like Lord Clarendon and Lord Mayo were his enthusiastic friends; splendid gifts of plate, and flattering addresses were presented on his resignation, and, till the infirmities of old age intervened, he was frequently consulted upon Irish affairs by subsequent Governments."†

Besides being a clever man, he was evidently a very industrious and methodical one. It is said that there are hundreds of bound volumes of his notes and memoranda on a great variety of subjects; most of these volumes have passed to various learned societies in Ireland. There are four volumes of letters, with his notes, now in the Ordnance Survey Library at Southampton; three

* *Dictionary of National Biography.*

† *Edinburgh Review*, No. 336. Quoted in Whitworth Porter's *History of the Corps of R.E.* Vol. II.

of these deal with contouring, and one with levelling. The volumes are full of technical interest; one volume, in particular, contains a valuable series of examples of various methods of depicting hill features—experiments which range from 1824 to 1847. Some of these have a curiously modern look.

On his retirement Larcom was created a baronet and an Irish Privy Councillor. He had already been made a K.C.B. He died in 1879.

Here is a letter from William Denison to Larcom. Denison (afterwards Sir William Denison, and some time Acting Governor-General of India) was, when he wrote this letter, the first editor of the *Professional Papers of the R.E.*

Woolwich, March 4th, 1841.

My dear Larcom,

There is some comfort in corresponding with you: one always gets some encouragement or assistance, while from others one too often meets with just the reverse. I must say that with some few exceptions I have met with a very small allowance of support or assistance from my Brother Officers; no one seems ever to think that his comrades may be benefitted by the information he may have in his possession, and consequently everyone waits till a subject is actually suggested to him before he thinks of putting pen to paper, though were he conscious of the benefit it would be to himself in perfecting and extending the knowledge of the subjects he is conversant with, he would make a practice of embodying his knowledge in the shape of a paper. This, however, is a mere exhortation of bile. . . .

I am glad you are pleased with this volume. I hope to get something from Alderson about Acre. I saw a letter from him to Fox giving a very clear account of what was done there, and some very sound remarks about Sea Batteries when exposed to such heavy fire as is now brought to bear against them. . . . I was not aware of what you have been doing about contouring, but I am rejoiced to hear that you have succeeded in introducing it, upon the six-inch scale; it is the only mode of showing the ground. I have long been an advocate for it upon Plans of any size—on a small scale it would be absurd, but on the six-inch it will give you an enormous mass of information at a glance, relative levels, shape of ground, etc. I think it would be well worth a paper and should be very glad if you would take it up. . . . Shall you be able to establish your levels all round Ireland with the necessary degree of accuracy for general Tidal observations? Is there not a dispute as to the Sea Level? What do you take as your datum line? I have not seen the results of Whewell's work at Bristol; he seemed to have taken very great pains in his levelling. . . .

Thanks for your memoir of Hogan. I like the style of the figure of Dr. Doyle, though I dislike the allegorical figure of Ireland. I hope he will do justice to Drummond. I am working away in the Dockyard here. I am rather short for money this year.

Yours very truly,
W. DENISON.

Irish Place-Names and John O'Donovan.—In the course of the survey of Ireland it became necessary to ascertain the correct forms of spelling of the Irish place-names. This was no easy task. In every country the lapse of time results in a gradual corruption of place-names; but in Ireland, in addition to this natural cause of error, there was an artificial cause, due to the orders of the English Government in the seventeenth century. Larcom quotes an order of King Charles I, which states that the "barbarous and uncouth names of places" in Ireland much retard the reformation of the country, and directs "the Lord Lieutenant and Council to change such names into others more suitable to the English tongue, annexing the ancient names in every grant so altered." Colby fully appreciated the importance of getting correct forms, and, when Larcom took charge of the Mountjoy office, the latter threw himself heartily into the difficult work of restoring the names. Larcom says, "as for the orthography of the names engraved on the maps of the Ordnance Survey, the different spellings and *alias* names of every townland were collected from all accessible documents, some . . . of very great antiquity; and, finally, local enquiry and examination were made by an Irish scholar on the spot, to render the name ultimately adopted as nearly as possible consistent with the ancient orthography."* All this information was collected in *Name Books*, which now form a priceless record of Irish place-name study. Again, Larcom says that the full results of this investigation will only be seen in the future; it arose "from the desire to ascertain a correct orthography for the numerous names of places, more especially parishes and townlands, which alone amount to nearly 70,000. . . . These names were commonly of Irish origin, and frequently of great antiquity. Lieut. Larcom first began himself to study the Irish language, and investigate the names as they arose, but this was obviously insufficient."* Many of the names

"were in Latin, many in Irish, contained frequently in M.S. charters and grants. When all had been collected that libraries and records could furnish, an investigation by a qualified Irish scholar was made on the ground, where, by additional inquiries, conversation with the old inhabitants, and examination of the locality, little difficulty was experienced in discovering the meaning of the name, and its correct orthography. . . . the practice was to adopt that one among the modern modes of spelling, which was most consistent with the ancient orthography. The documents thus collected form in themselves a most valuable topographic library, such, perhaps, as no country in Europe possesses in the same condensed form."

The chief of the Irish scholars mentioned above was John O'Donovan. An excellent source of information with regard to

* Portlock's *Memoir of General Colby*.



JOHN O'DONOVAN, LL.D.
1806-1861.

*From a portrait painted in 1838 by C. Gray, R.H.A.
Reproduced by permission.*

his life is the account written by Mr. Henry Dixon in *An Leabarlann** for April, 1906. What follows is based, by permission, on this source, which should be referred to by all interested in the subject.

John O'Donovan was one of the five sons of Edmund O'Donovan, who belonged to a family that had settled in Kilkenny early in the seventeenth century. John was born at Atateemore in July, 1806. His father died when John was eleven. It is said that it was from an uncle that he first caught "that love for ancient Irish and Anglo-Irish traditions" which he preserved all the rest of his life. He says himself that he "transcribed Irish pretty well in 1819." Early in 1821 he was sent to school at Waterford; and in 1823 he went to a Latin school in Dublin, where he remained until 1827. In 1830, whilst staying in Queen's County for his health, he made extracts from the *Annals of the Four Masters* and read many books bearing on Irish history.

In this year, 1830, to use his own words, "I applied to Capt. Larcom, then Lieutenant Larcom, for employment. I had known Mr. Larcom since the year 1828, when I taught him some lessons in Irish, and he wrote to me immediately, offering me a situation at a very small stipend, of which I accepted after some hesitation. . .'

O'Donovan was immediately employed upon the investigation of place-names. The various forms of the names were written in *Name Books*, and each authority quoted. This involved much research into the history and topography of the district, in fact, here, as always, history, topography and philology went hand in hand. "To O'Donovan the work was of special import. To this work and to his great application may be attributed the wonderful knowledge of history, archæology, and topography displayed in the innumerable writings associated with his name." He was periodically sent out into the field; and, taking with him the information collected in the *Name Books*, he was able, by an examination of the locality and by questioning the old inhabitants; to fix with some certainty the correct forms of the names. "The system . . . of visiting each place was afterwards not followed out, and O'Donovan was asked to decide on the proper names of places he had never visited, a system which he protested against." His many letters to Larcom giving the results of his investigations are a mine of information on philological, historical, and archæological matters, and are frequently drawn upon.

It had been the intention of Colby and Larcom to publish a series of memoirs of the parishes of Ireland. This magnificent scheme was never carried out; or, rather, only one parish was so dealt with. This parish was Templemore in County Londonderry; and the *Templemore Memoir* was published, with the assistance

*Dublin. Browne & Nolan, Ltd.

of the British Association, in 1837. It gives an account of the topography, geology, botany, and zoology of the parish; a description of the towns and a history of the townlands; a third section deals with statistics, social economy and manufactures. "The preface written by Colonel Colby states that the section relating to history, archæology and antiquities was written by George Petrie and John O'Donovan."

In 1845 O'Donovan published his *Irish Grammar*; in 1851-56 there was published his translation of the *Annals of the Four Masters*, with introduction and notes; in 1849 he was appointed Professor of Celtic Languages in the Queen's College, Belfast; in 1856 O'Donovan was elected a corresponding member of the Royal Academy of Berlin, on the proposition of Jacob Grimm. He died at Dublin on the 9th December, 1861, and was buried in the Prospect Cemetery. Inscriptions on tombstones are usually of too flattering a nature to be regarded as reliable material for history; but the account of O'Donovan's work on his tombstone is accurate and just. It reads:—

By his Irish Grammar, his edition of the Annals of the Four Masters, his labours on the transcription and translation of the Brehon Laws, and his invaluable contributions to our knowledge of the topography and local history of his country made during his connection with the Ordnance Survey, he laid a sure foundation for sound and scientific Celtic Studies and established his position as a master of Irish Philology and Archæology. . .

O'Donovan was helped in his investigations by all classes of his countrymen. He writes, for instance, from Belfast on 15th March, 1834:—"Dr. Crolly, R.C. Bishop of Down and Connor, has given me the following letter to the Priests of the Diocese:—

'The Bearer, Mr. John O'Donovan, is employed by the Ordnance Surveyors to ascertain accurately the old Irish names of townlands, villages, etc., for the purpose of making the general and particular Maps of Ireland, and its different counties, as perfect as possible. In this useful, laudable, and patriotic pursuit I trust that he will obtain from the Catholic clergy every assistance which they can afford in order that Mr. O'Donovan may be enabled to accomplish his interesting and important object.'

O'Donovan's letters to Larcom at the Mountjoy office are full of interest to this day and are written in a free and natural style, very different from that of most official reports. Thus, on the 23rd April, 1834, he writes from Castlewellan:—

"I have this day made a pilgrimage to Sliabh Domanghairt [Slieve Donard on the maps, 2,800-ft. high]. I have been induced from many motives—I. To endeavour to get the names of the Mourn Mountains from its lofty summit. . . . 2. To gratify a curiosity excited in my mind by

the gigantic appearance of the mountain itself from every part of the county, and by the following passage in Colgan's *Acta S.S.*:—"In the territory of Iveagh and Diocese of Dromore, there are two churches dedicated to St. Domangard, one (which is at the foot of a very high mountain overhanging the eastern sea) is called Rath Murbhuidlg by the ancients, but at this date Machaire Ratha; *the other* on the *summit* of that lofty mountain, *far removed from the habitation of every human being*, and which is frequented by great multitudes of pilgrims, etc. Hence this mountain, which was called Sliabh Slainge by the ancients, is at this day commonly called Sliabh Domhangaird from this Saint.' My third reason was, I suppose, to wash off in S. Domangard's well the many sins I have committed by cursing dogs, ganders, over-inquisitive people, and petty country landlords."

Downpatrick, April 29th, 1834:—"Please to desire Lieut. James [afterwards Sir Henry James] to insert into the *Name Books* the names of all the mountains, rocks, streams, valleys, loughs, etc., that are to appear on the maps of the barony of Mourne. . . These mountains bear very curious aboriginal names, and I am very anxious to have a perfect list of them lest I might omit any. . ."

Downpatrick, May 2nd, 1834:—

"In the parish of Tyrella there is a townland called Ballykinler, which Vallency, Beauford, and in all probability O'Reilly, would have explained, the *Town at the Head of the Sea* . . . but as soon as I heard it pronounced by an old Irishman, I said it must mean the *Town of the Candlestick* (horrid name!!), and silly conjecture for any sensible person! Be it so, say I—but turn to the fact. Look at Harris's *History of the County of Down*, 1744, and you will find, Ballykinler lower, middle, upper . . . formed the parish of *Ballykinler*, the titles of which were appropriated to Christ Church, Dublin, for WAX LIGHT. . ."

O'Donovan's letters to Larcom were presented by the Ordnance Survey to the Royal Irish Academy. The three letters above quoted are taken from *An Leabarlann*, for June, 1909, a number which deals with the letters of O'Donovan, written in 1834, from County Down.

X.—THE SIX-INCH SURVEY OF SCOTLAND AND THE NORTH OF ENGLAND.

THE END OF THE FIRST HUNDRED YEARS.

The Six-Inch Survey of Scotland and the North of England.

—At the end of the year 1837 the general situation was the following :—Three-quarters of the one-inch map of England and Wales had been finished ; the six-inch survey of Ireland was approaching completion ; but nothing had been done for Scotland, except the original sketch map of 1747-55, and an incomplete triangulation on which work had been stopped in 1825. It was clearly the turn of Scotland, and influential corporations and individuals moved the Government to approve of the execution of a six-inch map of that country. Thus, in 1837, the Town Council of Edinburgh presented to the Treasury a memorial, from which the following extracts are taken :—

“ The form and position of headlands, and even of considerable islands, not only in Arrowsmith’s map, but in our best charts, are erroneously given, and sometimes dangerous rocks are totally omitted. For example, the distant rocks of the Stack and the Skerry, off the northern coast of Sutherlandshire, are left out by Arrowsmith, while the important islands of Barra and Rona are misplaced both in latitude and longitude. In some books and charts the nearest distance of the large island of Arran is stated or laid down as four miles from Bute, and in others as three miles from that island. Pladda Island Light is placed as 16 north of Ailsa Craig ; whereas its true distance is only 10.20 ! . . .

“ Your Memorialists are informed, that of the great triangulation of Scotland, by which the positions of the principal objects are ascertained, the greater part was executed nearly twenty years ago, though the results have not yet been published ; and that the remaining part can be soon accomplished at a small expense.”

They also pressed for the general Survey of Scotland to be proceeded with. Other addresses and memorials on the subject were submitted to the Government by various public bodies in Scotland.

The question was brought to the notice of Parliament, and a motion for the production of memorials on the subject was brought forward by Sir R. Musgrave. The upshot was that a six-inch survey of Scotland and of the six northern counties of England was approved by the Government.

Sir Henry James, then Director of the Survey, writes in 1859 :—

“The survey of Ireland was completed on the six-inch scale; and though it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties in the South of Scotland on that scale.”

The triangulation of Great Britain was taken up again in 1838. In July and August of that year we find Colby, with Lt.-Colonel Robe and Lt. Robinson, on the summit of Ben Hutig (or Hutich), on the north coast of Sutherland. From this year until 1852, when it was finished, the work proceeded steadily. The observers for the first three or four years were Lt.-Col. Robe, Captains Robinson, Pidon and Hornby and Lieut. Da Costa.

A change of custom took place in 1840-41. Until then, all the observations of the principal angles were made by officers, as is still the case on the Survey of India. But in 1840, Corporal Donelan, R.S.M., observed some angles with the 12-inch theodolite in Ireland; and, in 1841, Corporal Steel, R.S.M., observed some angles with the 18-inch theodolite in Yorkshire. Thereafter, it became increasingly common to employ non-commissioned officers on this duty, and by the time the triangulation was completed it might be said that three-quarters of the total number of the angles had been observed by them. The observers most to be remembered, in this connection, are—giving them their later ranks—Sergt.-Major Steel, Colour-Sergeants Donelan and Winzer, Sergeants Bay and Jenkins, and Corporal Stewart; between them they observed at no fewer than 149 principal stations, out of a total of 228 in the British Isles.

The Completion of the Original Six-Inch Survey of Ireland.—The original object of the six-inch survey of Ireland, at its commencement in 1825, was the accurate delineation of the boundaries of counties, baronies, parishes and townlands. Later, however, it became necessary to show all the detail that could be drawn on the scale. Larcom writes :—

“At this time (1843) another circumstance had arisen. The early northern counties had not been surveyed with the degree of detail which had been attained in the south. . . . The tenement valuation, now introduced for the Poor Law, required this detail. Accordingly, on the memorials of the northern counties, the Government allowed the maps to be revised.”

Sir Henry James, writing in 1859, thus describes the matter :—

“We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands,

which was at first supposed would be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We consequently had again to proceed to the north and complete the survey. . . . Our parties are now finishing it—they are in Armagh. . . . And when that is finished I trust it will close the six-inch survey of Ireland."

The revision, so described, was not finally completed and published until 1863; but the original survey was finished in 1846, just before Colby retired. This original survey was complete as regards the southern counties, but in the north was only in skeleton—as laid down by the Select Committee. We have seen that the maps of the first county to be finished, namely Londonderry, were submitted by Colby to King William IV. in 1833.

So far we have dealt principally with a horizontal survey which made no attempt to show vertical relief. In the thirties this latter question came to the fore, and the advent of railways made the matter a practical one.

Levelling and Mean Sea Level.—The first lines of spirit-levelling undertaken by the Survey were those run in the year 1837, in the north of Ireland, to connect the larger lakes with the sea. These observations and those carried out between Axmouth and Portishead, by a committee of the British Association, under the direction of Whewell, in 1837-38, showed that much greater accuracy was obtained by levelling than by the observation of vertical angles. In 1839 levelling was definitely adopted in the Survey of Ireland for the purpose of fixing altitudes. The first levelling of Ireland was finished in 1843. The datum for Ireland was fixed as the level of a low water spring tide, observed at Poolbeg Lighthouse, in Dublin Bay, on the 8th April, 1837. If we compare the values based on this datum with those based on mean sea level, we shall find that all the heights on Irish maps are about 8-ft. too great.

In 1840 the original primary levelling of Great Britain was commenced; this was not completed until 1860.

The question now arose as to what datum should be chosen for Great Britain, and, after consultation with Airy, Colby caused to be carried out a series of tidal observations at 22 stations round the coast of Ireland, in June, July and August, 1842. The observations were taken on a tide-pole every five minutes, for one complete tide a day. The results confirmed the opinion that mean sea level would form the best datum. To obtain this datum for Great

Britain, tidal observations were made at the Victoria Dock, Liverpool, in 1844, taking the mean of high and low water. These observations were made at five-minute intervals, extending over about an hour around high and low water, and lasted from the 7th to the 16th March. Owing to the short period during which observations lasted, the old Liverpool datum was not minutely accurate; but it served its purpose well for nearly eighty years. It is now superseded by the new datum, which is mean sea level at Newlyn, in Cornwall, "as derived from the mean of the hourly readings recorded by the automatic tide gauge there for the period of six years from 1st May, 1915, to 30th April, 1921." It is of some interest to note that the mean of six years' readings differs from the mean of 10 years' readings (up to April, 1925) by less than a tenth of an inch, and that the probable variation of one year's mean from the mean of the ten years is about half an inch. This amount is about the same as the probable annual fluctuation found at nine tidal stations in India, which is 0.6 inch. The next step, after having settled the datum and the method of determining the heights of the level net-work, was to devise a suitable system of showing the ground-forms.

Contours.—A contour has been defined as "the outline of the intersection of a gravitational equipotential with the irregularities of the earth's surface"; but even this somewhat formidable definition is not quite correct, having in mind the actual method in use. The *Oxford Dictionary* defines a contour line as "a line representing the horizontal contour of the earth's surface at a given elevation," and this description, though not minutely exact, will do for most purposes. The same Dictionary quotes *Ansted*, who, in his *Geology* of 1844, remarks on "the laying down on the map a system of what are called contour-lines; by which is meant lines of equal altitude above a certain standard level." According to Colonel Berthaut:

"La première idée des courbes de niveau remonte, en réalité à 1729. A cette époque déjà, l'arpenteur hollandais Cruquius avait imaginé de définir le lit de la Merwède à l'aide de courbes d'égale sonde. En 1737 Philippe Buache représenta de même le fond de la Manche. Mais, comme le faisait remarquer la Commission de 1802, c'est le Corps de Génie qui le premier, et bien avant les ingénieurs géographes, sut définir les accidents du sol par des courbes de niveau. . . . Le chef de bataillon du génie Haxo, dans ses projets de 1801 pour Rocca d'Aufo, employa le premier régulièrement les sections horizontales, à l'échelle de 500'."*

To this account may be added that Buache, above mentioned, "published a contoured map of the English Channel, but did not

* *La Carte de France*. Colonel Berthaut, Service Géographique de l'Armée, 1898. Vol. I., p. 139.

touch the land, 1752. Ducarla is said in 1771 to have developed the idea practically, not knowing of Buache's work."[†]

We have seen that, in 1777, Dr. Charles Hutton, F.R.S., for the purpose of determining the attraction of Schiehallien on the plumb-bob, "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude."[‡] Hutton's idea was evidently quite independent of those quoted above, and Hutton's appears to be the first application of the idea to the land surface. But, however that may be, it was forgotten.

With regard to the date of the first use of contouring in this country, Larcom, in a letter to *The Civil Engineer and Architects' Journal* of November, 1843, states that contours have been applied to the representation of ground "for more than half a century (*i.e.*, before 1793), especially to military plans, where the relative command of ground is of great importance; for which purpose all officers of engineers are instructed in contouring."

In the Ordnance Survey Library, at Southampton, there are four volumes of manuscripts, bound together by Sir Thomas Larcom, dealing chiefly with contouring and levelling. In three of the volumes there are prefaces in Larcom's handwriting. These volumes give a very clear history of the adoption of contouring by the Ordnance Survey, especially in Ireland. In the introduction to the first volume, which has the title, *Contouring*, 1841-45, Larcom writes:—

"A general map on the scale of one-inch to the mile was an original portion of the Irish Survey ordered by the House of Commons, but it was properly deferred until the outline survey on the larger scale of six inches to the mile was sufficiently advanced to furnish the reduced outline in readiness for the delineation of the ground upon it. In 1831 it was so, and the best and most experienced officer on the English Survey was transferred to Ireland to take charge of it (Lieut. Dawson). He was stationed at Londonderry, around which the six-inch work was already completed. I had myself been employed on the English Survey and was very familiar with the general map of that country. But my subsequent experience on the Irish Survey had led me to the conviction that the more perfect outline obtained by the Content Survey in Ireland required that the hills also should be inserted by a more rigorous process than the sketching used in England. This could, I thought, be obtained in no way so well as by the introduction of lines of equal altitude, in the French mode, which Mr. Dawson (the father of Lieut. Dawson) had taught to the cadets by the name of contouring, but which had never been practically used in England for the maps. For this purpose I was anxious that Lieut. Dawson should adopt contouring, and I was allowed to supply him with outline maps and proper instruments. It did not

[†] From a note by Colonel H. G. Lyons, D.Sc., F.R.S.

[‡] *Philosophical Transactions*, 1778.

then succeed, because Dawson was soon called away to a succession of temporary duties in England . . . till, in 1838, he was permanently withdrawn to a civil situation."

It will be noted that Larcom attributes to the elder Dawson the introduction of the word "Contouring." This would, perhaps, be about 1800.

In 1841 Larcom was sent

"A young officer of no experience whatever, who had never been employed on the Survey at all, he was forced upon me by Colby, but was so entirely unsuited to the work that it became necessary in 1843 to relieve him. Thus more valuable time was lost. But during the 12 years which had elapsed since 1831, practical science had greatly advanced and the value of correct topography had become more and more appreciated. Railways alone, which during that time had become introduced, were sufficient to enforce the necessity for correct altitudes and differences of level; and contours had therefore assumed yet greater and more general importance. They had now become a necessary adjunct to the six-inch plans themselves. The Ordnance, however, remained opaque, and it required a Parliamentary Commission (Sir J. Young's, 1843) and the representation of scientific and local bodies to impress on that heavy Board the necessity of allowing us to keep pace with the advancing knowledge of the age. Gradually, however, even this was accomplished, and when Lieut. Leach succeeded to the duty in 1843, the field was nearly clear for him to move freely. The contouring had been begun at Londonderry, and been dropped. Then, on a whim of Colby's, moved to south; then to Kilkenny, with, in that case, a good object, viz., an effort to produce the contours in sufficient time to insert on the six-inch sheets, then in process of engraving . . . the young officer . . . was succeeded by an admirable man (Lieut. Leach), but too late to overtake the six-inch work. . . Leach began systematically to carry on the two duties together (revision and contouring), and he did both satisfactorily. Much energy, in spite of many checks, gradually succeeded, and all continued to go on well till 1846, when I left the Survey."

In Larcom's second volume of letters he says that this part of the story

"Begins with the movement at the British Association in favour of contouring, at the Cork meeting in 1843. Next, the desire for more accurate knowledge of levels in aid of the sanitary improvement of large towns in England in 1844—for which our (Irish) contoured sheets were produced as examples. Then, the movement of the Northern Irish Counties for revision as well as contouring. The value of contouring had, in fact, become fully recognised, and the Ordnance could no longer withhold their assent."

The volume also contains some correspondence relating to the proposal to have the cadets at Woolwich instructed in contouring; nothing effective being done till Captain Stotherd, who had been trained on the Irish Survey, became Professor. "It was then combined with Surveying, and continued (1839 to 1843)."

But, perhaps the most unexpected contents of the volume are

the accounts of the various experiments made by the elder Dawson, Larcom and others, and show hill features on a map. The examples bound up in this book date between 1824 and 1847. We have first an inked-in field sketch by T. Budgen, as practised on the first one-inch Survey of England; then essays in light and shade by Larcom in 1824; then some brush and pencil drawings by Dawson and a fine bit of chalk lithography; horizontal hachures; close contours; layer shading of County Kilkenny; and layer shading with the relief emphasised, of 1843—we might have had layered Ordnance maps as early as that year; hills in plastic low relief; and a curious, but effective, example of contours as fine raised lines. These experiments are worth study and almost deserve a monograph to themselves. They show that our predecessors were much alive to the importance of the subject, and that eighty or ninety years ago there were no methods, which we practice now, with which they were not acquainted, and that they had also tried others which we have forgotten.

In Great Britain contouring was begun about the same time as in Ireland. "Contour parties" first appear in the returns in 1843.

In the midst of all this technical activity there came an administrative change which was to affect the future of the Survey very materially. This change, the removal of the headquarters from the Tower to Southampton, came about chiefly as a result of a fire in the Tower. And this must now be described.

The Fire in the Tower of London.—The offices of the Ordnance Survey, the drawing room and the stores, were housed in some buildings touching the upper old storehouse and to the east of it, in the Tower of London. This storehouse was to the north of the White Tower, that is, on the far side from the river. The upper old storehouse is so described in a map drawn about 1685; later it was known as the Grand Storehouse. It was, in fact, an Armoury which had been begun by James II and completed by William III. This Armoury was destroyed by a fire which broke out on the 30th October, 1841. The following extract from the *Times* describes the circumstances:—*

"1st November. On Saturday night last at 10.30 p.m. fire broke out at the Round, or Bowyer, Tower to the north of the Stores.

"11 p.m. The fire reached the Armoury or Store House.

"11.20 p.m. The roof fell in.

"12.30 p.m. Heat was so great between the Armoury and the White Tower that some of the engines were burnt.

"1 a.m. All attention was directed to save the White Tower and St. Peter's Church. The lead on the White Tower was melted. 'By this time a plentiful supply of water had been obtained.'

* The writer is indebted to Major C. J. Foulkes, B.Lit., F.S.A., Curator of the Armouries, for this reference.



VIEW OF THE RUINS OF THE GRAND STOREHOUSE IN THE
TOWER OF LONDON,

After the Fire which broke out on 30th October, 1841.

Reproduced from a Sketch preserved in the Tower, by permission
of the Curator of the Armouries.

" 2 a.m. Some signs of abating. ' Prior to this a new cause of alarm arose in the Map Office. This was in very great danger, which was averted by the exertions of the firemen, and the very efficient assistance of the troops.'

" 3rd November. Brick Tower totally destroyed.

" 5th November. At 10 o'clock last night the fire was still raging in the west wing of the building.

" 6th November. ' The Map Office, which occupies the north-east corner of the Quadrangle, and which has suffered very materially from the action of the fire, is now quite deserted. It had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton, and many of the presses and fittings, having been seriously injured by hasty removal on the night of the fire, the Board of Ordnance have directed that suitable apartments shall be immediately prepared for them at the above port.' The Board of Ordnance Meeting : Colonel Peel in the Chair.

" 9th November. Wet blankets were hung over the north face of the White Tower to prevent the flames cracking the stone work.'

The chief loss which the Survey suffered was the destruction of Ramsden's Zenith Sector. The standard bars were saved ; the four theodolites, the 3-ft. R.S., the 3-ft. B.O., the 2-ft. by Troughton and Simms, and the 18-in. by Ramsden, were all in the field. The " long room," where Drummond's light was first tried, which occupied the upper floor of the Armoury, was, of course, destroyed.

A small point arises as to the want of water with which to fight the flames when the fire first broke out at 10.30 p.m., on the 30th October. In the Fire Officer's report it is stated that no water was supplied by the Water Company's mains, and water could only be drawn from tanks, from the moat or from the Thames. It appears, from information kindly furnished by the Hydrographer, that it was high water about 1.45, that is, about three hours after the outbreak was discovered.

" *The Annual Register*,† describing ' the Awful Conflagration at the Tower' of London, states that : A sentinel fired his musket to give the alarm, the troops turned out, the tower engines, 9 in number, started to play, or rather, to work, and engines of the Fire Brigade hurried up from all over the metropolis. Unfortunately the tide was out and the tanks under the Tower afforded but an inadequate supply of water. By 11 o'clock the destruction of the Round Tower was complete, the Armoury was involved, there were fears for the Jewel Tower and its contents, especially when it was remembered that the keys to the cases were in the possession of the Lord Chamberlain. However, they were broken into and the 'regalia, crowns, sceptres and other valuables of Royalty' were carried to the Governor's residence. ' A new cause of alarm arose in the Map Office, which contains some very valuable maps, records, etc., catching fire. That, however, was soon got under, and all the property placed in safety.' "

It was supposed that the fire originated in the armourer's forge

in the Round Tower. It would appear that all the Survey maps, stores and documents were saved, except Ramsden's Zenith Sector.

The Ordnance Survey moves to Southampton.—In the extract from the *Times*, above quoted, it is stated that "it had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton;" but this desire was certainly not the official reason for the move. In the *Minutes of Evidence taken before the Select Committee on Army and Ordnance Expenditure*, 1849, occur these passages:—†

"Major-General Charles R. Fox [Surveyor-General of the Ordnance] called in; and examined.

"Sir J. Graham: You have heard the evidence which has just been given; have you formed any opinion upon the subject of that evidence?—Yes, the Map Office, which has been lately transferred to Southampton might, I think, in the event of these rooms being vacated, be brought back to the Tower, thereby saving the constant journeys which take place to and from Southampton, and a good deal of postage.

"Do you think it would be more convenient, considering the growing importance of the surveying establishment, that it should be in the metropolis, and not at Southampton?—I am not so competent to give an answer upon that as many others might be, but I think it would be preferable.

"Mr. V. Smith: Is the Map Office now at Southampton in public premises?—It was an old barrack.

"Sir J. Graham: Why was Southampton selected?—On account of having this vacant place, I believe.

"Therefore, it was not that Southampton was the most convenient place for this particular duty, but because it was the only place where accommodation could be found at the time?—Certainly.

"In your opinion, if accommodation could be found in the metropolis, for every purpose of rapid communication and central position, it would be an advantage?—I should say decidedly so.

Major-General Charles R. Fox was perfectly right. It was not for the benefit of the national survey, nor for the good of the public, that the headquarter offices were moved to Southampton. The Ordnance Survey affords a rare example of the administration of a great survey being carried on in a provincial town. The only other case of the kind that readily comes to mind is that of Italy, which has its Istituto Geografico Militare in Florence, and not in Rome. But France, Germany, Spain, Belgium, India, the United States, and hosts of other countries, have their national surveys properly housed in the national capitals. The result of having had the administrative offices fixed at Southampton during the past eighty-four years has been to give the Survey a certain extra degree of independence, at the cost of its getting

† The writer is indebted to Mr. F. J. Hudleston, of the War Office, for this reference.

somewhat out of touch with the great offices of the Government and with the scientific and business activities of the nation. Certainly, from 1842 onwards, there comes a difference in Colby's relations with the Honourable Board; he is no longer able to go in and out in the old way, and discuss matters as they arise. No longer is he able to dine at Airy's hospitable table on Sundays, or to meet the astronomers, or engineers, or geologists, or geographers as frequently as he used to meet them in the past. But the change was not wholly for the worse. There was more room at Southampton than there ever could be in the Tower, and the various technical departments were now more free to develop. But the choice of Southampton was clearly a kind of accident, whether the Survey Officers wished to go there or not; and the ideal solution would have been to build an establishment in the outskirts of London, say at Kensington.

The history of the "old barrack" at Southampton is the following: Sometime about the end of the eighteenth century, probably, cavalry barracks were built on the ground now occupied by the Survey buildings. These barracks were, in 1816, taken over by the Duke of York's Royal Military School, then called the Royal Military Asylum. This well-known institution is a military school, founded for the training of the sons (and formerly, also, daughters) of soldiers. It was opened at Chelsea in 1803. "The Peninsula War was followed by such a great increase in the number of pupils of the School at Chelsea, that branch establishments were opened at Southampton, and one for infants at Parkhurst, Isle of Wight. . . The alterations at Southampton were commenced on the 24th June, 1816, and finished in the following year. The expense of altering a cavalry barracks to a school for children, including additions to building, and the purchase of ground, from 1816 to December 31st, 1830, amounted to £15,955 17s. 2d. The boys and girls occupied the school from 1817 to 1823, when all the boys, except the infants, were transferred to Chelsea, the girls at the latter place going to Southampton. The number of pupils at Southampton during the years 1817-1823 was 400. After the girls were transferred to Southampton their number was gradually reduced. . . . The year 1840 saw the end of our branch at Southampton."*

The open space at the foot of the Avenue, outside the Survey Office, is still known as Asylum Green, and thus perpetuates the memory of the twenty-three years of the existence of the Royal Military Asylum at Southampton. It must be repeated that the occupation of this old converted barrack school by the Survey was not due to any motives of policy, and was not approved because

* From a memorandum by Mr. Lewis C. Rudd, of the British Museum, an Old Boy of the Duke of York's School.

Southampton was a specially suitable place for the Survey headquarters, but came about chiefly "because it was the only place where accommodation could be found at the time."

The change of headquarters put the Survey, as has been said, a little out of touch with the scientific societies and scientific men of the metropolis. Amongst those scientific men one should specially mention Airy, who took the place that Dr. Charles Hutton filled in early years, in that he was frequently consulted by the officers of the Survey and the Board of Ordnance. Airy had so much to do with the geodesy of the operations that it seems desirable to give a brief account of his work, in so far as it affected the survey.

Airy.—Airy was born in 1801, and after holding the appointments of Lucasian Professor of Mathematics, and Plumian Professor of Astronomy, at Cambridge, was, in 1835, appointed Astronomer Royal, in succession to John Pond. His influence on the Ordnance Survey was very marked. He was always accessible to Colby and to others, like Yolland, who were concerned with the scientific aspects of the work. He remained Astronomer Royal for forty-six years, that is, until 1881; but it was chiefly in the early part of his long tenure of that appointment that his influence was felt in the Survey. Airy's *Figure of the Earth* was adopted by the Survey shortly after 1830, when it was published in the *Encyclopædia Metropolitana*. As the maps of the Survey are still plotted on this figure, and as the *Encyclopædia Metropolitana* of 1830 is not very accessible, it is, perhaps, desirable to explain how Airy arrived at his figure.

At that date it would have been possible to use 14 arcs of meridian and four longitudinal arcs. Airy rejected the latter, no doubt wisely. As to the meridional arcs, he noted that the greatest discordances occurred when observations in mountainous countries were made use of; it was, of course, well known in those days that mountain masses attract the plumb-bob. He, therefore, rejected the arcs, such as the Arc of Peru, measured in mountainous regions, and he was left with eight arcs from which to derive his figure. These eight arcs were: two French arcs, the American arc (Mason and Dixon), the English arc from Dunnose to Burleigh Moor, two Indian arcs, Gauss's Hanoverian arc, and Struve's Russian Arc; the two longest being the French arc of 12° from Formentera to Dunkirk, and Lambton's and Everest's arc of 16° measured in India. Airy refused to adopt the method of least squares, and used only the terminal latitude of each arc; in fact, his method of calculation was arbitrary and differs widely from modern practice. The elements of Airy's figure are:—

$$a \text{ (semi-axis major) in international metres, } 6,377,542$$

$$c \text{ the compression, or } \frac{a-b}{a} \text{ where } b \text{ is the semi-axis minor, } \frac{1}{299.3}$$



SIR GEORGE AIRY, D.C.L., LL.D., F.R.S.

1801—1892.

Astronomer Royal,

1835—1881.

This may be compared with Hayford's Figure, which, in 1924, was recommended by the International Union of Geodesy and Geophysics. In this Figure,

$$a = 6,378,388 \text{ international metres,}$$

$$c = \frac{1}{297}$$

As compared with the most recent Figure, Airy's has, thus, a semi-axis major which is 846 metres too short, and it has somewhat too small a compression. But the effect of those differences on the maps of the British Isles is negligible: no practical or theoretical purpose would be served by recomputing the geographical positions on the map, and it is unlikely that any figure other than Airy's will ever be used for the Ordnance Survey of these Islands.

Mr. H. L. P. Jolly has shown that the adoption of Hayford's figure, in place of Airy's, would alter the latitude of Cape Wrath by about $3\frac{1}{2}$ seconds, and would alter the longitude of Achill Island (off the coast of Mayo) about $5\frac{1}{2}$ seconds of arc; in each case assuming Greenwich to be the origin of the computation. If the changes were made, there would be no difference in the linear accuracy of the maps, but the latitude and longitudes round the margins would be shifted slightly. It is, clearly, not worth doing.

The question may be asked, Why does the Survey require to use any figure of the earth? The answer is, that for such a small portion of the earth's surface as is covered by Great Britain, or by Ireland, a figure is not necessary for the construction of the maps themselves. The original six-inch maps of Ireland were, for instance, constructed without reference to any figure, no latitude or longitudes being marked on these sheets. The whole of Ireland could have been mapped on one meridian, and the whole of Scotland, without reference to the real shape of the earth. England, which stretches some 160 miles east and west of the central meridian of 2° W., would have required two meridians, but no accurate knowledge of the real shape of the earth would have been wanted for the large scale maps. Of course, when we come to map the British Isles as a whole, we must fix on some definite projection and have at least an approximate notion of the true shape of the earth. But the real necessity for the adoption of a figure becomes apparent when we consider that latitudes and longitudes must be shown on nautical charts of all descriptions, and that the accurate delineation of the shores of these islands on such charts is taken from the Ordnance Survey.

Airy's calculation of a figure was, then, necessary for the use of the Survey. It was by no means his only service to the Department. In the autumn of 1841 Colby consulted him as to the design of a Zenith Sector for the observation of latitudes. The instrument was to be more portable than Ramsden's, and to be of

such a nature that good results could be got from the work even of a single night. "The Astronomer Royal, with his usual readiness to oblige, gave the subject his immediate attention, and accordingly proposed, and subsequently superintended, the construction of the instrument." It differed from Ramsden's instrument chiefly in the substitution of spirit levels for a plumb-line, and in the solidity yet portability of the few parts comprising it. It was used, between the years 1842 and 1850, for determining the latitudes of five stations in Ireland and of twenty-two in Great Britain.

Another matter, affecting the Survey, which occupied Airy, was the question of tides and the level of the sea. We have seen that in the early days of the work "the low water mark" was taken as the datum for heights. Whewell remarked, in 1838, that surveyors and naval men are in the habit of assuming the surface of *low water* to represent the level of the sea, whereas it is not even approximately a level surface at all. Whewell recommended *mean water*, "the means of low and high water." Mean water is not quite the same thing as mean sea level, but it is not very different. The latter is now universally recognised as the proper datum.

Airy also, in 1844, determined the longitude of the trigonometrical point Feaghmaan, that point on the Island of Valentia, off the south-west coast of Ireland, which is the westerly termination of the great European Arc of parallel along 52° north; this he did by the transport of chronometers from Greenwich. This longitude was re-determined by telegraph in 1862.

Airy was also much interested in pendulum determinations of the density of the earth. In 1826, and again in 1828, he carried out experiments at the bottom of Dolcoath mine in Cornwall; and again, in 1854, at the bottom of Harton Colliery, 1,260 feet below sea level, he swung pendulums for the same purpose.

But enough has been said to show how considerable was Airy's activity in scientific matters affecting the Ordnance Survey, and what a fortunate thing it was that, for a long series of years, he should have occupied, as it were, the position of official scientific adviser to Colby and his successors. Airy resigned his position as Astronomer Royal in 1881, being then eighty years old; he died in 1892. In the *Dictionary of National Biography* his son is quoted as summing up his father's scientific character in these words: "His nature was eminently practical, and his dislike of mere theoretical problems and investigations was proportionately great." No doubt he found in the work of the Survey just those practical applications of science which most attracted him.

A few letters from Airy to Colby have been preserved. Amongst them, perhaps the most interesting is the following, written in 1850, after Colby had retired. The latter had evidently been asking for Airy's views on education:—

"About the education of your sons, I cannot help you much in regard to treatises. I never expect very much from education; I think, perhaps, not so much as you do. Taking, for instance, the general subject of mathematics, with the view to its ulterior application to the business of science that may turn up in life, it appears to me that all that can be done is this: First, to give a perfect habitual familiarity with the machinery of mathematics, for example, with the general process of algebra and with the principal properties of circles and squares, etc. Secondly, to give what may be called a mathematical drill, to enable the mind to appreciate demonstration, and to see, in many cases, towards what conclusions the premises must lead without following them completely. But as to preparing the mind (otherwise than in this general way) for more than a very small fraction of the wants that will occur, I consider it desperate. For the second of the purposes that I mention, I think the modern school of mathematics (employing differential calculus, etc., when geometrical considerations will do as well) much inferior *in general* to the geometrical school: and so, I think, do most persons who have attended carefully to the results of academical education. Pray give Mrs. Airy's remembrances and mine to Mrs. Colby and believe me, my dear sir,

Yours truly,
G. B. AIRY.

Two more letters to Colby:—

Royal Observatory, Greenwich.

MY DEAR SIR,

1841, October 4th.

To-morrow (Tuesday) between two and three will be perfectly convenient to me. I shall, therefore, expect you, Yolland and Simms, about that time: dinner will be ready between three and four, and you then will be pleased to dine with us. This order being issued by Mrs. Airy there is no escape from it. You will notify accordingly to Yolland: I am just writing to Simms.

Yours very truly,
G. B. AIRY.

MY DEAR SIR,

1842, January 10th.

I am much concerned to find that you are laid up by illness. But as it *has* come, I hope you will indulge it well. Your life has been one of most incessant activity, and I think that Nature is giving you a hint that a little quiet, especially in a severe season, is not only comfortable, but also necessary. . . ."

Yolland.—All who have had occasion to study the geodesy of the British Isles will remember that we owe a great deal, in this connection, to Captain William Yolland. In 1842 Yolland wrote the account of the *Astronomical Observations* made with Ramsden's Zenith Sector; this account discusses the latitudes of 10 stations, determined with Ramsden's instrument, between the years 1802 and 1818, with the addition of some observations at Greenwich in 1836. In 1847 he published an admirable work on the *Measure-*

ment of the Lough Foyle Base, a measurement which had been carried out some twenty years earlier. And in 1852 he published a bulky and elaborate report upon the *Astronomical Observations* made with Airy's Zenith Sector, at 27 stations, during the years 1842 to 1850. These three works are the standard authorities on the observations with which they deal, and are written in an admirably scientific spirit.

The writer of these books, so important in the scientific history of the Survey, was born in 1810, was commissioned as a Second-Lieutenant in the Royal Engineers in 1828, and became a Second Captain in 1843. He was posted to the Ordnance Survey in 1838, about the time that Colby left Ireland, and when the question of the six-inch Survey of Scotland was being settled. Yolland was greatly trusted by Colby, who, in 1842, placed him in charge of the operations at the headquarter offices at Southampton. Late in 1846, Colby, having made up his mind to retire, recommended Yolland as his successor. But Colby had reckoned without the Board of Ordnance; and, indeed, it does not appear that he had taken any adequate steps to pave the way and to secure the concurrence of the Board. The removal of the headquarters of the Survey from the Tower to Southampton had put Colby a little out of touch with the authorities in London, and Burgoyne's appointment as Inspector-General of Fortifications seems to have had the effect of still further hindering Colby's approach to the Master-General. Things were very different from what they had been in the twenties in that respect. However that may be, Yolland was not the senior of those serving under Colby; there were two captains senior to him, and from a military point of view it is difficult to see how the appointment could have been made. Colby had not taken early measures to ensure his being succeeded by an officer of sufficient competence and seniority. In making the recommendation he writes Sir John Burgoyne that,

"An objection may arise to the appointment of so young an officer as Captain Yolland; the continuance of peace has made promotion slow, but he is about the same age (37 years), and has about the same length of service (19 years), which I had, when I succeeded the late Major-General Mudge in charge of the Survey in 1820: and I have upwards of eight years' personal observation of his close attention to the various duties, and of the results of his management, to warrant me in proposing his name."

Apart from seniority, and assuming that Portlock was not available, Yolland was without doubt the right man. In a letter to him, dated 19th March, 1847, from Douglas Galton, there occurs this passage:—

"The high and deserved praise of the present state of the Survey makes me the more regret that the new Superintendent has been appointed. I was talking about it to Harness the other day. He says

Matson asked him his opinion as to who should succeed Colby, and he says that it never occurred to him that any one except yourself could be named to it, that everyone who knew anything about the Survey knew that all improvements of late years had been introduced at your suggestion, and that although it is quite fair that General Colby should have praise due to those improvements, because he placed you in that situation, yet it is not fair that on his retirement a fresh person knowing nothing of the subject should be brought in to gain credit from your brains."

However, Sir John Burgoyne either would not, or could not, overcome the difficulty of Yolland's want of seniority, and a complete outsider was appointed. Yolland remained on the Survey for seven years more; but there was inevitable friction with his new chief, and in 1852 he was transferred from Southampton to the Irish Survey. In 1854 he left the Survey for good—but not for the good of the Survey—and was appointed an Inspector of Railways under the Board of Trade. In 1856 he was a member of the Commission appointed to consider the training of cadets for the scientific corps of the army. In 1859 he was elected a Fellow of the Royal Society. In 1877 he became the Chief Inspector of Railways, a post which he retained until his death in 1885.

Yolland was an able and popular officer. The testimony of men like Galton, Harness and Colby, and the good opinion held of him by Airy, are conclusive as to his ability; and as to his popularity, it is to be noted that, when he left Southampton for Ireland, in November, 1852, the Mayor and Corporation presented him with an address in acknowledgment of the interest which he had taken in the welfare of the town.*

Colby's Successor.—Sir John Burgoyne, apparently on his own initiative, and in spite of Colby's strong protest, recommended to the Board of Ordnance that Colby should be succeeded by Lieut.-Colonel L. A. Hall, R.E., and this officer became Superintendent of the Ordnance Survey, as the title then was, in April, 1847. Lt.-Col. Hall had had no previous acquaintance with survey matters. In a letter dated 16th March, 1847, Colby remarks that the official documents on the case "will show most distinctly that neither Sir John Burgoyne nor Lord Anglesey have any notion that the charge of a great national survey requires any experience of the nature of such a duty."

No doubt Hall had some good qualities which made him acceptable to the Board. His appointment was, however, something like a confession of failure on the part of the authorities, for it was known to all that he would have to rely upon Yolland. And for five-and-a-half years he did rely upon Yolland, who, in difficult circumstances, maintained the reputation of the Department, under

* *Dictionary of National Biography. Art. Yolland.*

a chief who was a mere administrator. It was Yolland, for instance, whose evidence was sought by commissions and parliamentary committees. The experiment was not a very happy one, and was drastically terminated by the Board after a few years' trial.

Colby was furious at Hall's appointment, and by letter and in personal interviews expressed himself with much freedom to the authorities in London. But Hall remained Superintendent until a year or two after Colby's death. It is, perhaps, significant that Colby having died in October, 1852, Hall sent Yolland to Ireland the month after; no doubt the strain had become rather more than either could bear. The Survey was then left without anyone at headquarters who understood the trigonometrical or astronomical work, until young Clarke joined in 1854. This appointment of Clarke is, by the way, very much to Hall's credit, and the scientific tradition was maintained, with the slight break mentioned, until 1881.

Some Miscellaneous Letters.—From Charles Macintosh to Colby:—

Red Bull Wharf, Upper Thames St.,

15th February, 1826.

"I now send you a specimen of muslin; as I believe, in all respects properly water proofed; and capable of resisting any test. I fear the colour is too dark for doing maps upon; but think, with care, that evil may also be remedied. . . ."

From Sir George Everest, shortly to be Surveyor-General of India, to Colby:—

Oriental Club, Hanover Square,

27th June, 1829.

"I am induced by the kindness of your offer when I last had the pleasure of seeing you to take a journey to Ireland this summer to witness the working of the machinery of your beautiful system in the field. I am too late, I fear, for anything connected with the base line measurement, but there will still be a great deal to interest me, I feel persuaded. . . ."

From the same, dated November 23rd, 1829, describing two sections of the Indian arc, and ending:—

"Now I want your similar data to compare with. Give me all you have and all my data are at your service. . . . P.S. The Court of Directors have made me Surveyor-General of India—tell this to Robert Boyd."

From the Secretary to the Birmingham and London Rail Road Company to the Board of Ordnance, 69, Cornhill, 23rd May, 1831:—

"The Company formed for the purpose of establishing a railroad communication between London and Birmingham, to which I am Secretary, have derived so much benefit from the published Ordnance Surveys in the course of the examination which they are making of the intermediate country, that I am anxious to obtain for our Surveyors the additional advantage of access to the documents which are not before the public."

From Henry Raper, author of the celebrated treatise on *The Practice of Navigation*, to Colby, 12, Milton Street, Dorset Square, April 29th, 1839:—

"MY DEAR SIR,

"I take the liberty of enclosing you a prospectus or two of a work which is now printing, and on which I think I have mentioned to you I have been for some time employed.

"The prospectus contains an account of the first volume, which I call *practice*, in order that the public may not feel themselves obliged to buy two volumes when one contains all that they want. I need not trouble you with further remarks on the first volume or part, than to observe that I have omitted Surveying altogether as not belonging to the place of the spectator on the surface of the earth; besides which, it is trifling both with the reader and the subject to pretend that surveying is to be learnt in three pages and a half. . . .

"I would not have occupied your time with these details, but that as your opinion will be of great consequence to the character of my work, I am anxious that you should be prepared to expect not merely a *technical* but an *educational* object in the composition; for I cannot but think that the only way to promote precision and clearness of ideas in our merely practical men is to place before them the matters they have to deal with, already digested with every attention to unity and purity of design, and the utmost distinctness of arrangement, and further, that this precision of ideas is more likely to become, insensibly, a habit, than to be inculcated by any precepts.

"The plan that I have adhered to involves the principle that practice should come *before* theory, as it appears to me rather inconsequent that a man should learn theory first—for the word theory implies specific knowledge of an end or fact which theory is to explain. In fact, if for 'stargazing' you read 'walking' the absurdity of saying 'study the doctrine of equilibrium in order to be able to walk,' becomes absurd enough. . . .

Believe me,

My dear Sir,

Yours very sincerely,

H. RAPER.

Raper's *Practice of Navigation* was published in 1840, and he was awarded a gold medal by the Royal Geographical Society for this work. The projected second volume on "Theory" was never published.

From Colby to Captain Henry James (afterwards Director of the Ordnance Survey), 7th May, 1845:—

"When I undertook to direct the Survey of Ireland I considered that it was the first essential measure for the pacification and improvement of the country, and I gave very strict orders to prevent any political or sectarian interference in the survey duty. The selection of the persons to be employed was solely guided by their supposed fitness for the work they were to do, and their advancement or removal depended upon their fitness or unfitness for their work, as proven by trial. I never allowed any enquiry as to their religious creeds, or for whom or against

whom they had voted at any election. But I certainly did prohibit those employed from attending political meetings, to prevent, as far as my influence would go, any party politics from continuing to disturb the peace of the country. I believe that these instructions are pretty generally known in Ireland, and I have not been aware that Captain Larcom has deviated from them. . ."

The following remarks, which are in Colby's handwriting, seem to be part of the draft of a farewell order :—

. . . "After the decease of my much esteemed predecessor, the late Major-General Mudge, the Duke of Wellington did me the honour of placing the Ordnance Survey under my direction.

"And when the House of Commons ordered a Survey of Ireland on a scale of six inches to one mile, as the basis for a new valuation of the land in that country, His Grace also confided to me the direction of that Survey. The entire Survey of a large country, with the minutiae of detail and accuracy required for a valuation of land, had no precedent of any similar work to guide its arrangements. I, therefore, devised new methods which I proposed for His Grace's sanction. I had learned from Major-General Sir Charles Pasley, the skill and intelligence which the Royal Sappers and Miners evinced in the acquirement of his course of instruction. And I proposed a military system with officers of Royal Engineers, soldiers of Royal Sappers and Miners, and assistants. From His Grace the Duke of Wellington, his Secretary, the Lord FitzRoy Somerset, and Viscount Hardinge, then Clerk of the Ordnance, I obtained every requisite authority and much valuable aid. It is, therefore, highly gratifying to my feelings to have an opportunity of expressing my gratitude for their early aid in enabling me to produce the present prosperous state of the Survey."

Let us, then, glance at the state of the Survey during Colby's last year of office.

The State of the Survey in 1846.—In 1846 the Survey was almost exactly one thousand strong, including all officials, both in Great Britain and in Ireland. The strength of the Survey of Ireland had come down with a run after 1840, when there were nearly 2,000 men employed in that country. The reason for this was that the original six-inch survey was approaching completion; the field work was finished in 1844 and all the maps were engraved by 1846. Only a small staff of about 250 men was left, after that year, to carry on the revision.

The original six-inch Survey of Ireland had taken rather more than 20 years to execute, and had cost about £800,000.

It should be noted that, in 1851, Captain William Yolland gave evidence before the Select Committee on the Ordnance Survey of Scotland, that the six-inch survey of that country "could be done in 15 years at a cost of about £750,000," including the contouring.

In January, 1846, there were 735 persons employed upon the Ordnance Survey in Great Britain and 132 of this total were

stationed at Southampton. The offices of the detail survey were at Dumfries, Liverpool, Preston, Wakefield and York. The main work was the original six-inch survey; this was published in "full" sheets, each 36 inches from east to west, and 24 inches from north to south. The sheets were engraved on copper. Work was going on chiefly in Kirkcudbrightshire, Lancashire and Yorkshire.

There was that innovation, a contouring department, thirty-five strong, and this was occupied in contouring Lancashire. Great attention was paid to the correct delineation of county and other administrative boundaries.

There were also the "5 Feet" plans in hand, that is, plans on a scale of 1:1056; and a few one-inch sheets were being engraved. But the main energies of the Survey were directed to the revision of the six-inch map of Ireland, and the execution of the original six-inch maps of Scotland and of the northern counties of England.

Colonel William Yolland gave evidence before the Registration and Conveyancing Commission to the following effect: "The orders under which the Survey proceeds at present contemplate the completion of the six northern counties of England and the whole of Scotland on the six-inch scale, with maps of the towns on the 60-inch scale, this part of the country not having been previously surveyed." . . . "When I say 'towns,' I mean towns having a population exceeding 4,000 inhabitants."

In studying the reports and returns of these years, one gets the impression of a carefully organized department, carrying out its duties methodically, by means of a well-considered system of division of labour, controlled by an efficient headquarter office. In fact, Colby's large-scale map-making machine was working well.

The End of the First Hundred Years.—Colby's machine was working well, and in that state we will take leave of it, when, in March, 1847, he retired from the Army and the Survey. The machine was working so well that it underwent but little change for a generation, or more, to come. We have attempted to trace, for the first hundred years, the growth of this survey, the finest of all national surveys in its completeness and usefulness. And we will end with the picture of old Roy, in his house in Argyll Street, urging in his last paper, written just before he died in July, 1790, that the trigonometrical operation so successfully begun should be extended over the whole country; and, as we may suppose, casting his thoughts back to his share in those early explorations of the Highlands, which were to lead at last, though not in his lifetime, to the creation of the Ordnance Survey.

